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THE DEVELOPMENT OF POLITICAL INSTITUTIONS.

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IV.—POLITICAL DIFFERENTIATION.

THE general law, that like units exposed to like forces tend to integrate, was in the last chapter exemplified by the formation of social groups. The clustering of men who are similar in kind, when similarly subject to hostile actions from without, and similarly reacting against them, we saw to be the first step in social evolution. Here the correlative general law, that in proportion as the like units of an aggregate are exposed to unlike forces they tend to form differentiated parts of the aggregate, has to be observed in its application to such groups, as the second step in social evolution.

The primary political differentiation originates from the primary family differentiation. Men and women being, by the unlikenesses of their functions in life, exposed to unlike influences, begin from the first to assume unlike positions in the social group as they do in the family group: very early they respectively form the two political classes of rulers and ruled. And, how truly such dissimilarity of social positions as arises between them is caused by dissimilarity in their relations to surrounding actions, we shall see, on observing that the one is small or great according as the other is small or great. When treating of the *status* of women, it was pointed out that to a considerable degree among the Chippewas, and to a still greater degree among the Clatsops and Chinooks, "who live upon fish and roots, which the women are equally expert with the men in procuring, the former have a rank and influence very rarely found among Indians." We saw also that in Cueba, where the women join the men in war, "fighting by their side," their position is much higher than usual among rude peo-

ples ; and, similarly, that in Dahomey, where the women are as much warriors as the men, they are so regarded that, in the political organization, "the woman is officially superior." On contrasting these exceptional cases with the ordinary cases, in which the men, solely occupied in war and the chase, have unlimited authority, while the women, occupied in gathering miscellaneous small food and carrying burdens, are abject slaves, it becomes manifest that diversity of relations to surrounding actions initiates diversity of social positions. And, as we before saw, this truth is further illustrated by those few uncivilized societies which are habitually peaceful, such as the Bodo and Dhimáls of the Indian hills, and the ancient Pueblos of North America—societies in which the occupations are not, or were not broadly divided into fighting and working, and severally assigned to the two sexes; and in which, along with a comparatively small difference in the activities of the sexes, there goes, or went, small difference of social *status*.

So is it when we pass from the greater or less political differentiation which accompanies difference of sex to that which is independent of sex—to that which arises among men. Where the life is permanently peaceful, definite class-divisions do not exist. One of the Indian Hill-tribes, to which I have frequently referred as exhibiting the honesty, truthfulness, and amiability accompanying a purely industrial life, may be instanced. Hodgson says, "All Bodo and all Dhimáls are equal—absolutely so in right or law—wonderfully so in fact." The like is said of another peaceful and amiable Hill-tribe : "The Lepchas have no caste distinctions." And among a different race, the Papuans, may be named the peaceful Arafuras as displaying a "brotherly love with one another," and as having no divisions of rank.

As, at first, the domestic relation between the sexes passes into a political relation, such that men and women become, in militant groups, the ruling class and the subject class, so does the relation between master and slave, originally a domestic one, pass into a political one as fast as, by habitual war, the making of slaves becomes general. It is with the formation of a slave-class that there begins that political differentiation between the regulating structures and the sustaining structures which continues throughout all higher forms of social evolution.

Kane remarks that "slavery in its most cruel form exists among the Indians of the whole coast from California to Behring's Straits, the stronger tribes making slaves of all the others they can conquer. In the interior, where there is but little warfare, slavery does not exist." And this statement does but exhibit, in a distinct form, the truth everywhere obvious. Evidence suggests that the practice of enslavement diverged by small steps from the practice of cannibalism. Concerning the Nootkas, we read that "slaves are occasionally sacri-

ficed and feasted upon"; and if we contrast this usage with the usage common elsewhere, of slaying and devouring captives as soon as they are taken, we may infer that the keeping of captives too numerous to be immediately eaten, with the view of eating them subsequently, leading, as it would, to the employment of them in the mean time, led to the discovery that their services might be of more value than their flesh, and so initiated the habit of preserving them as slaves. Be this as it may, however, we find that very generally, among tribes to which habitual militancy has given some slight degree of the appropriate structure, the enslavement of prisoners becomes an established habit. That women and children taken in war, and such men as have not been slain, naturally fall into unqualified servitude is manifest. They belong absolutely to their captors, who might have killed them, and who retain the right afterward to kill them, if they please. They become property, of which any use whatever may be made.

The acquirement of slaves, which is at first an incident of war, becomes presently an object of war. Of the Nootkas we read that "some of the smaller tribes at the north of the island are practically regarded as slave-breeding tribes, and are attacked periodically by stronger tribes"; and the like happens among the Chinooks. It was thus in ancient Vera Paz, where periodically they made "an inroad into the enemy's territory, . . . and captured as many as they wanted"; and it was so in Honduras, where, in declaring war, they gave their enemies notice that "they wanted slaves." Similarly with various existing peoples. St. John says that "many of the Dyaks are more desirous to obtain slaves than heads, and in attacking a village kill only those who resist or attempt to escape." And that in Africa slave-making wars are common needs no proof.

The class-division, thus initiated by war, afterward maintains and strengthens itself in sundry ways. Very soon there begins the custom of purchase. The Chinooks, besides slaves who have been captured, have slaves who were bought as children from their neighbors; and, as we saw when dealing with the domestic relations, the selling of their children into slavery is by no means uncommon with savages. Then the slave-class, thus early enlarged by purchase, comes afterward to be otherwise enlarged. There is voluntary acceptance of slavery for the sake of protection; there is enslavement for debt; there is enslavement for crime.

Leaving details, we need here note only that this political differentiation which war begins is effected, not by the bodily incorporation of other societies, or whole classes belonging to other societies, but by the incorporation of single members of other societies, and by like individual accretions. Composed of units who are detached from their original social relations and from one another, and absolutely attached to their owners, the slave-class is, at first, but indistinctly separated as a social stratum. It acquires separateness only as fast as there arise

some restrictions on the powers of the owners. Ceasing to stand in the position of domestic cattle, slaves begin to form a division of the body-politic, when their personal claims begin to be distinguished as limiting the claims of their masters.

It is commonly supposed that serfdom arises by mitigation of slavery; but examination of the facts shows that it arises in a different way. While, during the early struggles for existence between them, primitive tribes, growing at one another's expense by incorporating separately the individuals they capture, thus form a class of absolute slaves, the formation of a servile class, considerably higher, and having a distinct social *status*, accompanies that later and larger process of growth under which one society incorporates other societies bodily. Serfdom originates along with conquest and annexation.

For whereas the one implies that the captured people are detached from their homes, the other implies that the subjugated people continue in their homes. Thomson remarks that, "among the New-Zealanders, whole tribes sometimes became nominally slaves when conquered, although permitted to live at their usual places of residence, on condition of paying tribute, in food, etc."—a statement which shows the origin of kindred arrangements in allied societies. Of the Sandwich Islands government when first known, described as consisting of a king with turbulent chiefs, who had been subjected in comparatively recent times, Ellis writes, "The common people are generally considered as attached to the soil, and are transferred with the land from one chief to another." Before the late changes in Feejee, there were enslaved districts; and of their inhabitants we read that they had to supply the chiefs' houses "with daily food, and build and keep them in repair." Though conquered peoples, thus placed, differ widely in the degrees of their subjection—being at the one extreme, as in Feejee, liable to be eaten when wanted, and at the other extreme called on only to give specified proportions of produce or labor—yet they remain alike as being undetached from their original places of residence. That serfdom in Europe originated in an analogous way there is good reason to believe. In Greece we have the case of Crete, where, under the conquering Dorians, there existed a vassal population, formed, it would seem, partly of the aborigines and partly of preceding conquerors, of which the first were serfs attached to lands of the state and of individuals, and the others had become tributary land-owners. In Sparta the like relations were established by like causes: there were the helots, who lived on, and cultivated, the lands of their Spartan masters, and the periœci, who had probably been, before the Dorian invasion, the superior class. So was it also in the Greek colonies afterward founded, such as Syracuse, where the aborigines became serfs. Similarly in later times and nearer regions. When Gaul was overrun by the Romans, and again when Romanized Gaul was overrun by the

Franks, there was little displacement of the actual cultivators of the soil, but these simply fell into lower positions: certainly lower political positions, and M. Guizot thinks lower industrial positions. Our own country, too, furnishes good illustrations. In ancient British times, writes Pearson, "it is probable that, in parts at least, there were servile villages, occupied by a kindred but conquered race, the first occupants of the soil." More trustworthy, but to the like effect, is the evidence which comes to us from old English days and Norman days. Professor Stubbs says: "The ceorl had his right in the common land of his township; his Latin name, villanus, had been a symbol of freedom, but his privileges were bound to the land, and when the Norman lord took the land he took the villein with it. Still the villein retained his customary rights, his house and land and rights of wood and hay; his lord's demesne depended for cultivation on his services, and he had in his lord's sense of self-interest the sort of protection that was shared by the horse and the ox." And of kindred import is the following passage from Innes: "I have said that, of the inhabitants of the Grange, the lowest in the scale was the *ceorl*, *bond*, *serf*, or villein, who was transferred like the land on which he labored, and who might be caught and brought back if he attempted to escape, like a stray ox or sheep. Their legal name of *nativus*, or *neyf*, which I have not found but in Britain, seems to point to their origin in the native race, the original possessors of the soil. . . . In the register of Dunfermline are numerous 'genealogies,' or stud-books, for enabling the lord to trace and reclaim his stock of serfs by descent. It is observable that most of them are of Celtic names."

Clearly, a subjugated territory, useless without cultivators, was left in the hands of the original cultivators because nothing was to be gained by putting others in their places, even could an adequate number of others be had. Hence, while it became the conqueror's interest to tie each original cultivator to the soil, it also became his interest to let him have such an amount of produce as to maintain him and enable him to rear offspring, and also to protect him against injuries which would incapacitate him for work.

To show how fundamental is the distinction between bondage of the primitive type and the bondage of serfdom, it needs but to add that, while the one can and does exist among savages and pastoral tribes, the other becomes possible only after the agricultural stage is reached; for only then can there occur the bodily annexation of one society by another, and only then can there be any tying to the soil.

Associated men, who live by hunting, and to whom the area occupied is of value only as a habitat for game, can not well have anything more than a common participation in the use of this occupied area: such ownership of it as they have must be joint ownership. Naturally, then, at the outset, all the adult males, who are at once hunters and

warriors, are the common possessors of the undivided land, encroachment on which by other tribes they resist. Though, in the earlier pastoral state, especially where the barrenness of the region involves wide dispersion, there is no definite proprietorship of the tract wandered over; yet, as is shown us in the strife between the herdsmen of Abraham and those of Lot respecting feeding-grounds, some claims to exclusive use tend to arise; and at a later half-pastoral stage, as among the ancient Germans, the wanderings of each division fall within prescribed limits. I refer to these facts by way of showing the identity established at the outset between the militant class and the land-owning class. For, whether the group is one which lives by hunting or one which lives by feeding cattle, any slaves its members possess are excluded from land-ownership—the freemen, who are all fighting men, become, as a matter of course, the proprietors of their territory. This connection, in variously modified forms, long continues through subsequent stages of social evolution, and could scarcely do otherwise. Land being, in early settled communities, the almost exclusive source of wealth, it happens inevitably that, during times in which the principle that might is right remains unqualified, personal power and possession of land go together. Hence the fact that, where, instead of being held by the whole society, land comes to be parceled out among component village communities, or among families, or among individuals, possession of it habitually goes along with the bearing of arms. In ancient Egypt "every soldier was a land-owner"—"had an allotment of land of about six acres." In Greece the invading Hellenes, wresting the soil from its original holders, joined military service with the land-ownership. In Rome, too, "every freeholder, from the seventeenth to the sixtieth year of his age, was under obligation of service, . . . so that even the emancipated slave had to serve, who, in an exceptional case, had come into possession of landed property." The like happened in the early Teutonic community. Joined with professional warriors, its army included "the mass of freemen, arranged in families, fighting for their homesteads and hearths": such freemen, or markmen, owning land partly in common and partly as individual proprietors. Similarly with the ancient English: "Their occupation of the land as *cognationes* resulted from their enrollment in the field, where each kindred was drawn up under an officer of its own lineage and appointment"; and so close was this dependence that "a thane forfeited his hereditary freehold by misconduct in battle."

Beyond the original connection between militancy and land-owning, which naturally arises from the joint interest which those who own the land and occupy it, either individually or collectively, have in resisting aggressors, there arises later a further connection. As, along with successful militancy, there progresses a social evolution which gives to a dominant ruler increased power, it becomes his cus-

tom to reward his leading soldiers by grants of land. Early Egyptian kings "bestowed on distinguished military officers" portions of the crown domains. When the barbarians were enrolled as Roman soldiers, "they were paid also by assignments of land according to a custom which prevailed in the imperial armies. The possession of these lands was given to them on condition of the son becoming a soldier like his father." And that kindred usages were general throughout the feudal period is a familiar truth: feudal tenancy being, indeed, thus constituted, and inability to bear arms being a reason for excluding women from succession. To exemplify the nature of the relation established, it will suffice to name the facts that "William the Conqueror . . . distributed this kingdom into about sixty thousand parcels, of nearly equal value, from each of which the service of a soldier was due," and that one of his laws requires all owners of land to "swear that they become vassals or tenants," and will "defend their lord's territories and title as well as his person" by "knight service on horseback."

That this original relation between land-owning and militancy long survived, we are shown by the armorial bearings of county families, as well as by their portraits of ancestors who are mostly represented in military costume.

Setting out with the class of warriors, or men bearing arms, who in primitive communities are owners of the land, collectively or individually, or partly one and partly the other, there arises the question, How does this class differentiate into nobles and freemen?

The most general reply is, of course, that since the state of homogeneity is by necessity unstable, time inevitably brings about inequality of positions among those whose positions were at first equal. Before the semi-civilized state is reached the differentiation can not become decided, because there can be no large accumulations of wealth, and because the laws of descent do not favor maintenance of such accumulations as are possible. But in the pastoral and still more in the agricultural community, especially where descent through males has been established, several causes of differentiation come into play. There is first that of unlikeness of kinship to the head-man. Obviously, in course of generations, the younger descendants of the younger become more and more remotely related to the eldest descendant of the eldest, and social inferiority arises: as the obligation to execute blood-revenge for a murdered member of the family does not extend beyond a certain degree of relationship (in ancient France not beyond the seventh), so neither does the accompanying distinction. From the same cause comes inferiority in point of possessions. Inheritance by the eldest male from generation to generation brings about the result that those who are the most distantly connected in blood with the head of the group are also the poorest. And then there coöperates

with these factors a consequent factor—namely, the extra power which the greater wealth gives. For when there arise disputes within the tribe, the richer are those who, by their better appliances for defense and their greater ability to purchase aid, naturally have the advantage over the poorer. Proof that this is a potent cause is found in a fact named by Sir Henry Maine: "The founders of a part of our modern European aristocracy, the Danish, are known to have been originally peasants who fortified their houses during deadly village struggles, and then used their advantage." Such superiorities of power and position once initiated are increased in another way. Already in the last chapter we have seen that communities are to a certain extent increased by the addition of fugitives from other communities—sometimes criminals, sometimes those who are oppressed. While, in places where such fugitives belong to races of superior type, they often become rulers (as among many Indian Hill-tribes, whose rajahs are of Hindoo extraction), in places where they are of the same race, and can not do this, they attach themselves to those of chief power in their adopted tribe. Sometimes they yield up their freedom for the sake of protection: a man will make himself a slave by breaking a spear in the presence of his wished-for master, as among the East Africans, or by inflicting some small bodily injury upon him, as among the Fulahs. And in ancient Rome the semi-slave class distinguished as clients originated by this voluntary acceptance of servitude with safety. But, where his aid promises to be of value as a warrior, the fugitive offers himself in that capacity in exchange for maintenance and refuge. Other things equal, he joins himself to some one marked by superiority of power and property, and thus enables the man already dominant to become more dominant. Such armed dependents, having as aliens no claims to the lands of the group, and bound to its head only by fealty, answer in position to the *comites* as found in the early German communities, and as exemplified in old English times by the "Huscarlas" (house-carls), with whom nobles surrounded themselves. Evidently, too, followers of this kind, having certain interests in common with their protector, and no interests in common with the rest of the community, become, in his hands, the means of usurping communal rights and elevating himself while depressing the rest.

Step by step the contrast strengthens. Beyond such as have voluntarily made themselves slaves to a head-man, others have become enslaved by capture in the wars meanwhile going on, others by staking themselves in gaming, others by purchase, others by crime, others by debt. And of necessity the possession of many slaves, habitually accompanying wealth and power, tends still further to increase that wealth and power, and to mark off still more the higher rank from the lower.

Certain concomitant influences generate differences of nature, physical and mental, between those members of a community who have at-

tained superior positions, and those who have remained inferior. Unlikenesses of *status* once initiated lead to unlikenesses of life, which, by the constitutional changes they work, presently make the unlikenesses of *status* more difficult to alter.

First there comes difference of diet and its effects. In the habit, common among primitive tribes, of letting the women subsist on the leavings of the men, and in the accompanying habit of denying to the younger men certain choice viands which the older men eat, we see exemplified the inevitable proclivity of the strong to feed themselves at the expense of the weak; and, when there arise class-divisions, there habitually results better nutrition of the superior than of the inferior. Forster remarks that in the Society Islands the lower classes often suffer from a scarcity of food which never extends to the upper classes. In the Sandwich Islands the flesh of such animals as they have is eaten principally by the chiefs. Of cannibalism among the Feejeeans, Seeman says, "The common people throughout the group, as well as women of all classes, were by custom debarred from it." These instances sufficiently indicate the contrast that everywhere arises between the diets of the ruling few and of the subject many. And then by such differences of diet, and accompanying differences in clothing, shelter, and strain on the energies, are eventually produced physical differences. Of the Feejeeans we read that "the chiefs are tall, well made, and muscular; while the lower orders manifest the meagerness arising from laborious service and scanty nourishment." The chiefs among the Sandwich-Islanders "are tall and stout, and their personal appearance is so much superior to that of the common people that some have imagined them a distinct race." Ellis, verifying Cook, says of the Tahitians, that the chiefs are, "almost without exception, as much superior to the peasantry . . . in physical strength as they are in rank and circumstances"; and Erskine notes a parallel contrast among the Tongans. That the like holds among the African races may be inferred from Reade's remark that "the court lady is tall and elegant; her skin smooth and transparent; her beauty has stamina and longevity. The girl of the middle classes, so frequently pretty, is very often short and coarse, and soon becomes a matron; while, if you descend to the lower classes, you will find good looks rare, and the figure angular, stunted, sometimes almost deformed."*

Simultaneously there arise, between the ruling and subject classes, unlikenesses of bodily activity and skill. Occupied, as those of higher rank commonly are, in the chase when not occupied in war, they have a life-long discipline of a kind conducive to various physical superiorities; while, contrariwise, those occupied in agriculture, in carrying of burdens, and in other drudgeries, partially lose what agility and ad-

* While writing, I find in the recently issued "Transactions of the Anthropological Institute" proof that, even now in England, the professional classes are both taller and heavier than the artisan classes.

dress they naturally had. Class-predominance is, therefore, thus further facilitated.

And then there are the respective mental traits produced by daily exercise of power, and by daily submission to power. The ideas, and sentiments, and modes of behavior, perpetually repeated, generate on one side an inherited fitness for command, and on the other side an inherited fitness for obedience; with the result that, in course of time, there arises on both sides the belief that the established relations of classes are the natural ones.

By implying habitual war among settled societies, the foregoing interpretations have implied the formation of compound societies. The rise of such class-divisions as have been described is, therefore, complicated by the rise of further class-divisions determined by the relations from time to time established between those conquerors and conquered whose respective groups already contain class-divisions.

This increasing differentiation which accompanies increasing integration is clearly seen in certain semi-civilized societies, such as that of the Sandwich-Islanders. Ellis enumerates their ranks as—"1. King, queens, and royal family, along with the councilor or chief minister of the king. 2. The governors of the different islands, and the chiefs of several large divisions. Many of these are descendants of those who were kings of the respective islands in Cook's time, and until subdued by Kamehameha. 3. Chiefs of districts or villages, who pay a regular rent for the land, cultivating it by means of their dependents, or letting it out to tenants. This rank includes also the ancient priests. 4. The laboring classes—those renting small portions of land, those working on the land for food and clothing, mechanics, musicians, and dancers." And, as shown by other passages, the laboring classes here grouped together are divisible into—artisans, who are paid wages; serfs, attached to the soil; and slaves. Inspection makes it tolerably clear that the lowest chiefs, once independent, were reduced to the second rank when adjacent chiefs conquered them and became local kings; and that they were reduced to the third rank at the same time that these local kings became chiefs of the second rank, when, by conquest, a kingship of the whole group was established. Other societies in kindred stages show us kindred divisions similarly to be accounted for. Among the New-Zealanders there are six grades; there are six among the Ashantees; there are five among the Abyssinians; and other more or less compounded African states present analogous divisions. Perhaps ancient Peru furnishes as clear a case as any of the superposition of ranks resulting from subjugation. The petty kingdoms which were massed together by the conquering Incas were severally left with the rulers and their subordinates undisturbed; but over the whole empire there was a superior organization of Inca rulers of various grades. That kindred causes produced kindred effects in

early Egyptian times is inferable from traditions and remains which tell us both of local struggles which ended in consolidation and of conquests by invading races; whence would naturally result the numerous divisions and subdivisions which Egyptian society presented: an inference justified by the fact that under Roman dominion there was a recomplication caused by superposing of Roman governing agencies upon native governing agencies. Passing over other ancient instances, and coming to the familiar case of our own country, we may note how, from the followers of the conquering Norman, there arose the two ranks of the greater and lesser barons, holding their land directly from the king, while the old English thanes were reduced to the rank of sub-feudatories. Of course, where perpetual wars produce, first, small aggregations, and then larger ones, and then dissolutions, and then reaggregations, and then unions of them, various in their extents, as happened in mediæval Europe, there result very numerous divisions. In the Merovingian kingdoms there were slaves having seven different origins; there were serfs of more than one grade; there were freedmen—men who, though emancipated, did not rank with the fully free; and there were two other classes less than free—the *liten* and the *coloni*. Of the free there were three classes—independent land-owners; freemen in relations of dependence with other freemen, of whom there were two kinds; and freemen in special relations with the king, of whom there were three kinds.

And here, while observing in these various cases how greater political differentiation is made possible by greater political integration, we may also observe that in early stages, while social cohesion is small, greater political integration is made possible by greater political differentiation. For the larger the mass to be held together, while incoherent, the more numerous must be the agents standing in successive degrees of subordination to hold it together.

The political differentiations which militancy originates, and which for a long time acquire increasing definiteness, so that intermixture of ranks by marriage is made a crime, are at later stages and under other conditions interfered with, traversed, and partially or wholly destroyed.

Where, throughout long periods and in ever-varying degrees, war has been producing aggregations and dissolutions, the continual breaking up and reforming of social bonds obscures the original divisions established in the ways described: instance the state of things in the Merovingian kingdoms just named. And where, instead of conquests by kindred adjacent societies, which in large measure leave standing the social positions and properties of the subjugated, there are conquests by alien races carried on more barbarously, the original grades may be practically obliterated, and in place of them there may arise grades originating entirely by appointment of the despotic conqueror. In parts of the East, where such overrunnings of race by race have

been going on from the earliest recorded times, we see this state of things substantially realized: there is little or nothing of hereditary rank, and the only rank recognized is that of official position. Besides the different grades of appointed state functionaries, there are no class distinctions, or none having political meanings.

A tendency to subordination of the original ranks and a substitution of new ranks is otherwise caused: it accompanies the progress of political consolidation. The change which has occurred in China well illustrates this effect. Gutzlaff says: "Mere title was afterward (on the decay of the feudal system) the reward bestowed by the sovereign, . . . and the haughty and powerful grandees of other countries are here the dependent and penurious servants of the Crown. . . . The revolutionary principle of leveling all classes has been carried in China to a very great extent. . . . This is introduced for the benefit of the sovereign, to render his authority supreme."

The causes of such changes are not difficult to see. In the first place, the subjugated local rulers losing, as integration advances, more and more of their power, lose, consequently, more and more of their actual if not of their nominal rank, passing from the condition of tributary rulers to the condition of subjects. Indeed, jealousy on the part of the monarch sometimes prompts positive exclusion of them from influential positions; as in France, where "Louis XIV systematically excluded the nobility from ministerial functions." Presently their distinction is further diminished by the rise of competing ranks created by state authority. Instead of the titles inherited by the land-possessing military chiefs, which were descriptive of their attributes and positions, there come to be titles conferred by the sovereign. Certain of the classes thus established are still of militant origin; as the knights made on the battle-field, sometimes in large numbers before battle, as at Agincourt, when five hundred were thus created, and sometimes afterward in reward for valor. Others of them arise from the exercise of political functions of different grades; as in France, where, in the seventeenth century, hereditary nobility was conferred on officers of the great council and officers of the chamber of accounts —officers who had habitually been of *bourgeois* extraction. The administration of law, too, presently originates titles of honor. In France, in 1607, nobility was granted to doctors, regents, and professors of law; and "the superior courts obtained, in 1644, the privileges of nobility of the first degree." "So that," as Warnkoenig remarks, "the original conception of nobility was in the course of time so much widened that its primitive relation to the possession of a fief is no longer recognizable, and the whole institution seems changed." These, with kindred instances, which our own country and other European countries furnish, show us both how the original class-divisions become blurred and how the new class-divisions are distinguished by being delocalized. They are strata which run through the integrated society,

having, many of them, no reference to the land, and no more connection with one place than another. It is true that, of the titles artificially conferred, the higher are habitually derived from the names of districts and towns: so simulating, but only simulating, the ancient feudal titles expressive of actual lordship over territories. The other modern titles, however, which have arisen with the growth of political, judicial, and other functions, have not even nominal references to localities. This change naturally accompanies the growing integration of the parts into a whole, and the rise of an organization of the whole which disregards the divisions among the parts.

More effective still, in weakening those primitive political divisions initiated by militancy, is increasing industrialism. This acts in two ways, firstly, by creating a class having power derived otherwise than from territorial possessions or official position; and, secondly, by generating ideas and sentiments at variance with the ancient assumptions of class-superiority. As we have already seen, rank and wealth are at the outset habitually associated. Existing uncivilized people still show us this relation. The chief of a kraal among the Koranna Hottentots is "usually the person of greatest property." In the Bechuana language "the word *kosi* . . . has a double acceptation, denoting either a chief or a rich man." Such small authority as a Chinook chief has, "rests on riches, which consists in wives, children, slaves, boats, and shells." So was it originally in Europe. In ancient Spain the title *ricos hombres*, applied to the barons, definitely identified the two attributes. Indeed, it is manifest that before the development of commerce, and while possession of land could alone give largeness of means, lordship and riches were directly connected; so that, as Sir Henry Maine remarks, "the opposition commonly set up between birth and wealth, and particularly wealth other than landed property, is entirely modern." When, however, with the arrival of industry at that stage in which wholesale transactions bring large profits, there arise traders who vie with, and exceed, many of the landed nobility in wealth, and when, by conferring obligations on kings and nobles, such traders gain social influence, there comes an occasional removal of the barrier between them and the titled classes. In France the progress began as early as 1271, when there were issued letters ennobling Raoul, the goldsmith—"the first letters conferring nobility in existence." The precedent, once established, is followed with increasing frequency, and sometimes, under pressure of financial needs, there grows up the practice of selling titles, in disguised ways or openly. In France, in 1702, the king ennobled two hundred persons at three thousand livres a head; in 1706, five hundred at six thousand a head. And then, the breaking down of the ancient political divisions thus caused, is furthered by that weakening of them consequent on the growing spirit of equality fostered by industrial life. In proportion as men are daily habituated to maintain their own claims while respecting the claims of others, which

they do in every act of exchange, whether of goods for money or of services for pay, there is produced a mental attitude at variance with that which accompanies subjection; and, as fast as this happens, such political distinctions as imply subjection lose more and more of that respect which gives them strength.

Class-distinctions, then, date back to the beginnings of social life. Omitting those small wandering assemblages which are so incoherent that their component parts are ever changing their relations to one another and to the environment we see that, wherever there is some coherence and some permanence of relation among the parts, there begin to arise political divisions. Relative superiority of power, first causing a differentiation at once domestic and social, between the activities and positions of the sexes, presently begins to cause a differentiation among males, shown in the bondage of captives; a master-class and a slave-class are formed.

Where men continue the wandering life in pursuit of wild food for themselves or their cattle, the groups they form are debarred from doing more by war than appropriate one another's units individually; but, where men have passed into the agricultural or settled state, it becomes possible for one community to take possession bodily of another community, along with the territory it occupies. When this happens, there arise additional class-divisions. The conquered and tribute-paying community, besides having its head-men reduced to subjection, has its people reduced to a state such that, while they continue to live on their lands, they yield up, through the intermediation of their chiefs, part of the produce to the conquerors; so foreshadowing what eventually becomes a serf-class.

From the beginning the militant class, being by force of arms the dominant class, becomes the class which owns the source of food—the land. During the hunting and pastoral stages, the warriors of the group hold the land collectively. On passing into the settled state, their tenures become partly collective and partly individual in sundry ways, and eventually almost wholly individual. But, throughout long stages of social evolution, land-owning and militancy continue to be associated.

The class-differentiation, of which militancy is the active cause, is furthered by the establishment of definite descent, and especially male descent, and the transmission of position and property to the eldest son of the eldest continually. This conduces to inequalities of position and wealth between near kindred and remote kindred; and such inequalities of wealth, once initiated, strengthen themselves by giving to the superior increased means of maintaining their power by accumulating appliances for offense and defense.

Such differentiation is increased, at the same time that a new differentiation is initiated, by the immigration of fugitives who attach

themselves to the most powerful member of the group, now as dependents who work, and now as armed followers—armed followers who form a class bound to the dominant man, and unconnected with the land. And since, in clusters of such groups, fugitives ordinarily flock most to the strongest group, and become adherents of its head, they are instrumental in furthering those subsequent integrations and differentiations which conquests bring about.

Inequalities of social position, bringing inequalities in the supplies and kinds of food, clothing, and shelter, tend to establish physical differences, to the further advantage of the rulers and disadvantage of the ruled. And, beyond the physical differences, there are produced, by the respective habits of life, mental differences, emotional and intellectual, strengthening the general contrast of nature.

When there come the conquests which produce compound societies, and, again, doubly compound ones, there come superpositions of ranks. And the general effect is that, while the ranks of the conquering society become respectively higher than those which existed before, those of the conquered become respectively lower.

The class-divisions thus formed during the earlier stages of militancy are traversed and obscured as fast as the many small societies are consolidated into one large society. Ranks referring to local organization are gradually replaced by ranks referring to general organization. Instead of deputy and sub-deputy governing agents who are the militant owners of the subdivisions they rule, there come governing agents who more or less clearly form strata running throughout the society as a whole—a concomitant of developed political administration.

Chiefly, however, we have to note that, while the higher political evolution of large social aggregates tends to break down the divisions of rank which grew up in the small component social aggregate, by substituting other divisions, these original divisions are still more broken down by growing industrialism. Generating a wealth that is not connected with rank, this initiates a competing power; and at the same time, by establishing the equal positions of citizens before the law in respect of trading transactions, it weakens those divisions which at the outset expressed inequalities of position before the law.

As verifying these interpretations, I may add that they harmonize with the interpretations of ceremonial institutions recently given. As the primary differences of rank result from victories, and as the primary forms of propitiation originate in the behavior of the vanquished to the vanquishers, so the later differences of rank result from differences of power which, in the last resort, express themselves in physical coercion, and so the observances between ranks are recognitions of such differences of power. When the conquered enemy is made a slave, and mutilated by taking a trophy from his body, we see simultaneously originating the deepest political distinction and the cere-

mony which marks it; and, with the continued militancy that compounds and recompounds social groups, there goes at once the development of political distinctions and the development of ceremonies marking them. And, as we before saw that growing industrialism diminishes the rigor of ceremonial rule, so here we see that it tends to destroy those class-divisions which militancy originates, and to establish others which indicate differences of position consequent on differences of aptitude for the various functions which an industrial society needs.

ORIGIN OF THE PLOW AND WHEEL-CARRIAGE.

By E. B. TYLOR, F.R.S.

THOUGH much has been written on that great engine of civilization, the plow, yet the whole line of evidence as to its development from the simplest and earliest agricultural implements seems never to have been put together, so that I venture to lay before the Anthropological Institute the present notes.

Not only the beginning of agriculture, but the invention of the plow itself, is prehistoric. The plow was known to the ancient Egyptians and Babylonians, and the very existence of these nations points to previous thousands of years of agricultural life, which alone could have produced such dense, settled, and civilized populations. It was with a sense of what the plow had done for them that the old Egyptians ascribed its invention to Osiris, and the Vedic bards said the Açvins taught its use to Manu, the first man. Many nations have glorified the plow in legend and religion, perhaps never more poetically than where the Hindoos celebrate *Sîtâ*, the spouse of Râma, rising brown and beauteous, crowned with corn-ears, from the plowed field; she is herself the furrow (*sîtâ*) personified. Between man's first rude husbandry and this advanced state of tillage lies the long interval which must be filled in by other than historical evidence. What has first to be looked for is hardly the actual invention of planting, which might seem obvious even to rude tribes who never practice it. Every savage is a practical botanist, skilled in the localities and seasons of all useful plants, so that he can scarcely be ignorant that seeds or roots, if put into proper places in the ground, will grow. When low tribes are found not tilling the soil, but living on wild food, as apparently all mankind once did, the reason of the absence of agriculture would seem to be not mere ignorance, but insecurity, roving life, unsuitable climate, want of proper plants, and, in regions where wild fruits are plentiful, sheer idleness and carelessness. On looking into the condition of any known savage tribes, Australians, Andamaners, Botocudos, Fuegians, Esquimaux, there is always one or more of these reasons to account for

want of tillage. The turning-point in the history of agriculture seems to be not the first thought of planting, but the practical beginning by a tribe settled in one spot to assist nature by planting a patch of ground round their huts. Not even a new implement is needed. Wandering tribes already carry a stick for digging roots and unearthing burrowing animals, such as the *kattu* of the Australians, with its point hardened in the fire (Fig. 1), or the double-ended stick which

FIG. 1.—AUSTRALIAN "KATTA."

Dobrizhoffer ("Abipones," part ii, chap. xiii) mentions as carried by the Abipone women to dig up eatable roots, knock down fruits or dry branches for fuel, and even, if need were, break an enemy's head with. The stick which dug up wild roots passes to the kindred use of planting, and may be reckoned as the primitive agricultural implement. It is interesting to notice how the Hottentots in their husbandry break up the ground with the same stone-weighted stick they use so skillfully in root-digging or unearthing animals (J. G. Wood, "Natural History of Man," vol. i, p. 254.) The simple pointed stake is often mentioned as the implement of barbaric husbandry, as when the Kurubars of south India are described as with a sharp stick digging up spots of ground in the skirts of the forest, and sowing them with ragy (Buchanan, "Journey through Mysore, etc.," in Pinkerton, vol. viii, p. 707); or where it is mentioned that the Bodo and Dhimál of northeast India, while working the ground with iron bills and hoes, use a four-foot two-pointed wooden staff for a dibble (B. H. Hodgson, "Aborigines of India," p. 181). The spade, which is hardly to be reckoned among primitive agricultural implements, may be considered as improved from the digging-stick by giving it a flat, paddle-like end, or arming it with a broad, pointed metal blade, and afterward providing a foot-step (see the Roman spade in Smith's "Dictionary of Greek and Roman Antiquities," s. v. "pala"). In the Hebrides is to be seen a curious implement called *caschrom*, a kind of heavy bent spade with an iron-shod point, which has been set down as a sort of original plow (Rau, "Geschichte des Pflugs," p. 16; Macculloch, "Western Islands," Plate 30); but its action is that of a spade, and it seems out of the line of development of the plow. To trace this, we have to pass from the digging-stick to the hoe.

All implements of the nature of hoes seem derived from the pick or axe. Thus the New Caledonians are said to use their wooden picks both as a weapon and for tilling the ground (Klemm, "Culturwissenschaft," part ii, p. 78). The *tima*, or Maori hoe (Fig. 2), from R. Taylor's "New Zealand and its Inhabitants," p. 423, is a remarkable curved wooden implement in one piece. It is curious that of all this class of agricultural implements the rudest should make its appearance in

Europe. Tradition in south Sweden points to waste pieces of once-tilled land in the forests and wilds as having been the fields of the old "hackers," and within a generation there was still to be seen in use on forest farms the "hack" itself (Fig. 3), made of a stake of spruce-fir, with, at the lower end, a stout projecting branch cut short and pointed (Hyltén-Cavallius, "Wärend och Wirdarne," part ii, p. 110; i, p. 43). Even among native tribes of America a more artificial hoe than this was found in use. Thus the hoe used by the North American women in preparing the soil for planting maize, after the old stalks had been burned, is described as a bent piece of wood, three fingers wide, fixed to a long handle (see Charlevoix, "Nouvelle France," Letter 23; Lafitau, "Mœurs des Sauvages Ameriquains," vol. ii, p. 76, and Plate 7). (I do not venture to copy the hoe shown in this plate: a mere fancy picture.) In other North American tribes the women hoed with a shoulder-blade of an elk or buffalo, or a piece of the shell of a tortoise fixed to a straight handle (see Loskiel, "Mission of the United Brethren in North America," p. 66; Catlin, "American Indians," vol. i, p. 121). From this stage we come up to implements with metal

FIG. 2.—"TIMA," OR MAORI HOE.

FIG. 3.—SWEDISH "HACK."

blades, such as the Caffre axe, which, by turning the blade in the handle, becomes an implement for hoeing (Lane Fox, "Lectures on Primitive Warfare," No. 2, p. 10). The heavy-bladed Indian hoe (Sanskrit, *kuddâla*), called *kodâly* in Malabar (Klemm, "Culturwissenschaft," part ii, p. 123), which is shown in Fig. 4, is one example of the iron-bladed hoe, of clumsy and ancient type. The modern varieties of the hoe need no detailed description here.

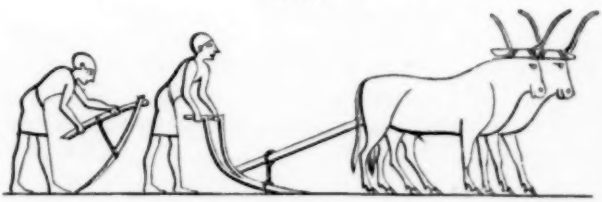
That the primitive plow was a hoe dragged through the ground to form a continuous furrow, is seen from the very structure of early plows, and was accepted as obvious by Ginzrot ("Wagen und Fahrwerke der Griechen und Römer," vol. i, and Klemm, "Culturwissenschaft," part ii, p. 78). The evidence of the transitions through which agricultural implements have passed in Sweden during the last ten centuries or so, which was unknown to these writers, is strongly confirmatory of the same view. It appears that the fir-tree hack (Fig. 3) was followed by a heavier wooden implement of similar shape, which

was dragged by hand, making small furrows; this "furrow-crook" is still used for sowing. Afterward was introduced the "plow-crook," made in two pieces, the share with the handle and the pole for drawing. The share was afterward shod with a three-cornered iron bill,

FIG. 4.—INDIAN HOE.

but the implement was long drawn by hand, till eventually it came to be drawn by mares or cows (Hyltén-Cavallius, part ii, p. 111). Thus in comparatively modern times a transformation took place in Sweden remarkably resembling that of which we have circumstantial evidence as having happened in ancient Egypt. The Egyptian monuments show a plow, which was practically a great hoe, being dragged by a rope by men (see Denon, "Antiquités de l'Egypte," vol. i, Pl. 68). Still more perfect is the plowing scene here copied in Fig. 5 (see Rosellini, "Monumenti dell' Egitto," Pl. 32, 33; Wilkinson, "Ancient Egyptians," chap. vi). Here the man who follows the plow to break up the clods is working with the ordinary Egyptian hoe, remarkable for its curved wooden blade longer than the handle, and prevented

FIG. 5.



from coming abroad by the cord attaching the blade to the handle half-way down. This peculiar implement, with its cord to hold it together, reappears on a larger scale in the plow itself, where the straight stick is lengthened to form the pole by which the oxen draw it, and a pair of handles are added by which the plowman keeps down and guides the plow. The valley of the Nile, where the lightness and richness of the alluvial soil are favored by the inundations with their fresh deposit of river-mud, was no doubt one of the regions where the higher agriculture earliest arose, and, looking at this sketch of hoeing and plowing, we might be tempted to think that here the transition

from the barbaric hoe to the civilized plow is to be seen as it first took place in the world. Egypt may possibly have been the birthplace of the plow; but so many forms of rude plows are to be found represented on coins and sculptures of the ancient world, that it is safer to be content with the general idea that they are enlarged and transformed hoes, without attempting to fix the date, place, and nation to which this inventive transformation belongs. The following figures

FIG. 6.

FIG. 7.

are selected from those copied by Ginzrot and Rau. The old Syracusan form (Fig. 6), as likewise some old Etruscan patterns, is remarkable as being so close to the original hoe pattern as not to have the tail or handle. This want is supplied in other rude forms of ancient Italy, of which Fig. 7 shows one. A more angular Roman form is thought to represent the ceremonial plow, with which the wall-line was traced in founding a new city, and Fig. 8 is another archaic form; the projection of the pole behind was for the plowman's foot to press the share down:

> "Depresso incipiat jam tum mihi taurus aratro
> Ingemere, et sulco attritus splendescere vomer."
> (Virgil, "Georgics," I, 45.)

Fig. 9 is Greek, from an early MS. of Hesiod's "Works and Days." Looking at forms of plow as rude as these to be seen at this day in Asia and in backward countries of Europe, one wonders to find that already in classic ages the husbandman had plows of construction far

FIG. 8.

FIG. 9.

more nearly approaching that of our best modern implement-makers. Pliny (xviii, c. 48), after describing the simpler kinds of plow, mentions that in Rhætia a plow with the addition of two small wheels had

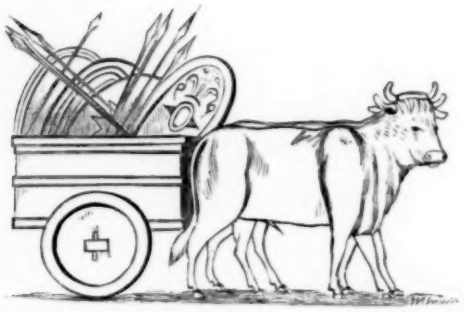
been recently invented, and was used for land already under tillage. He also mentions the coulter (*culter*). This knife, fixed in front to make the first cut ready for the share to turn the sod, is a great improvement on the primitive plows, where the plowshare has to do the whole work. In Pliny's time, though only forming part of some plows, it was evidently well known. Thus he recognizes the whole construction of the wheel-plow (Fig. 10) as figured by Caylus from an ancient gem. The ordinary modern plow used by the English farmer improves upon this rather in details of construction and material than in essential principle, though a new start in invention is taken by the self-acting plow, which no longer needs the plowman to follow at the plow-tail, and by the steam-plow, which substitutes engine-traction.

FIG. 10.

The plow, drawn by oxen or horses, and provided with wheels, has taken on itself the accessories of a wheel-carriage. But, when the plow is traced back to its earliest form of a hoe dragged by men, its nature has little in common with that of the vehicle. Though the origin of the wheel-carriage is even more totally lost in prehistoric antiquity than that of the plow, there seems nothing to object to the ordinary theoretical explanation (see Reuleaux, "Kinematics of Machinery," and others), that the first vehicle was a sledge dragged along the ground; that, when heavy masses had to be moved, rollers were put under the sledge, and that these rollers passed into wheels, forming part of the carriage itself. The steps of such a transition, with one notable exception which will be noticed, are to be actually found. The sledge was known in ancient Egypt (see the well-known painting from El Bersheh of a colossal statue being dragged by men with ropes on a sledge along a greased way, Wilkinson, "Ancient Egyptians," vol. iii). On mountain-roads, as in Switzerland, as well as on the snow in winter, the sledge remains an important practical vehicle. The use of rollers under the sledge was also familiar to the ancients (see the equally well-known Assyrian sculpture of the moving of the winged bull, in Layard's "Nineveh and Babylon," p. 110). If, now, the middle part of the trunk of a tree used as a roller were cut down to a mere axle, the two ends remaining as solid drums, and stops were fixed under the sledge to prevent the axle from running away, the result would be the rudest imaginable cart. I am not aware that this can be traced anywhere in actual existence, either in ancient or modern times; if found, it would be of much interest as vouching for this particular stage of invention of the wheel-carriage. But the stage which would be theoretically the next improvement is to be traced in practical use;

this is to saw two broad drums off a tree-trunk, and connect them by a stout bar through their centers, pinned fast, so that the whole turns as a single roller. The solid drum-wheel was used in the farm-carts of classic times (see the article "Plaustrum," by Yates, in Smith's "Dictionary of Greek and Roman Antiquities"). The ox-wagon here shown is taken from the Antonine column (Fig. 11); it appears to have solid wheels, and the square end of the axle proves that it and its drum-wheels turned round together in one. A further improvement was to make the wheel with several pieces nailed together, which would be less liable to split. The ancient Roman farm-carts were mostly made with such wheels, as are their successors which are used to this day with wonderfully little change, as in Greece and Portugal.

FIG. 11.

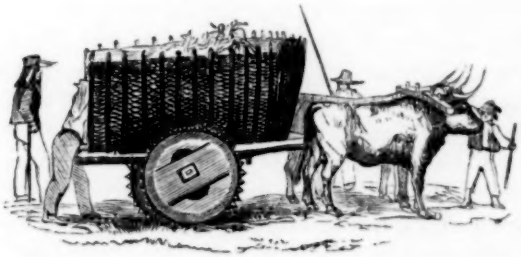


The bullock-cart of the Azores (Fig. 12) (from Bullar, "Winter in the Azores," vol. i, p. 121) is a striking relic from the classic world; its wheels are studded with huge iron nails, by way of tire. From old times it was common to make wooden rings, sockets, or bearings underneath the cart for the axle to turn in, much as children's toy-carts are made, as has often been remarked. But a drawing of a modern bullock-cart, taken near Lisbon, represents only a pair of pieces of wood acting as stops, so that the body of the cart can be lifted off its wheels. In looking at these clumsy vehicles, we certainly seem to have primitive forms before us. There is, however, the counter-argument, which ought not to be overlooked, and which in some measure accounts for the lasting-on of these rude carts, namely, that for heavy carting across rough ground they are convenient, as well as cheap and easily repaired. Considering that the railway-carriage builder gives up the coach-wheel principle, and returns to the primitive construction of the pair of wheels fixed to the axle turning in bearings, we see that our ordinary carriage-wheels turning independently on their axles are best suited to comparatively narrow wheels, and to smooth ground or made roads. Here they give greater lightness and speed, and especially have the advantage of easily changing direction and turning, which in

the old block-wheel cart can only be done by gradually slewing round in a wide circuit.

As early as history goes back, the carriage-builder had already begun to make spoked wheels with metal tires, whose well-made nave turned smoothly on the axle. It is needless here to extract from Wilkinson and Layard particulars of the beautifully made Egyptian and Assyrian chariots, nor to go into details of classic, mediæval, and modern carriage-building. As bearing on the origin of the art, it must be noticed that the point where the developments of the plow and car-

FIG. 12.



riage join is in the way of attaching the drawing oxen or horses, which was much alike in both. The pole and yoke was no doubt the original mode of draught, not only for the plow and the heavy ox-cart, where it may be often seen still, but also for the chariot and light car (see Schlieben, "Die Pferde des Alterthums," p. 154). The war-chariot, with its yoked steeds, has a remarkable similarity wherever we meet with it in the ancient world, which seems to point to its invention by some one particular nation, though which has not yet been made out, whence it spread to distant countries. How such inventions found their way is well shown in a point of detail, which incidentally shows how far the ancient Britons were from the uncivilized state popularly attributed to them, namely, their use (Mela iii, 6) of scythe-chariots, such as were used in Oriental armies, like that of Darius (Diod. Sic. xvii, 53), or of Antiochus Eupator, when he came into Judea with horsemen and elephants and three hundred scythe-chariots (2 Maccab. xiii, 2). War-chariots were from the first drawn by the pole. The Homeric chariots appear to have been without traces, as where, in the Iliad (vi, 40), Adrastus's scared horses snap the pole amid the tangled tamarisk, and set off straight for the city, evidently having nothing but the pole to hold them. In ancient Egypt, one inner trace was used, but the stress was on the pole. Eventually, in looking at the harness of various nations, we come to the present plan of draught by collar and traces. The change is interesting, as seeming to prove that the earliest use of draught-cattle is that still seen in the yoke of oxen. It has been argued by Pictet ("Origines Indo-Européennes," part ii, p.

94) that the yoke, Sanskrit, *yuga* = that which *joins*, was first invented for the pair of oxen to draw the plow with, it being likely that they were first put to this heavy work, and afterward used for drawing carts, rather than that the idea of drawing a cart by oxen should have occurred before putting them to plow. This, though not absolutely certain, seems a very reasonable argument; while the yoke and pole, being so much better suited to the ox than to the horse, point to oxen as the earliest draught-beasts. The history of successive changes seems well shown in the Latin *jumentum*, a beast of burden, from *jugumentum* = yoke-ment, which word keeps up the memory of the original yoke, though other modes of transporting burdens had come in. The Latin *jumentum* is used for the horse, etc., but not for the ox; and French *jument* has still further lost the old idea, now meaning merely a mare. One further remark is suggested by the harness of the ancient Egyptian chariot, where the yoke is provided with two saddles coming down on the withers of the horses. As is well known, cavalry was by no means general among the armies of the ancient world. The early Aryans, like the Homeric heroes, were charioteers, not horsemen, nor are there any ancient Egyptian horsemen to be seen on the monuments. On the other hand, the warriors of Palestine are there to be seen on horseback, and horse-soldiers appear on the Assyrian sculptures. In old times, however, the horseman is mostly seen riding a barebacked horse, or with a cloth or pad only. It seems to have been gradually that saddles proper began to be used in Assyria, and among the Greeks and Romans. Looking, now, at the Egyptian yoke-saddles of the chariots, one may suspect that from them were derived not only the harness-saddles in modern use, but also our riding-saddles.—*Journal of the Anthropological Institute.*

PHYSICAL EDUCATION.

By FELIX L. OSWALD, M. D.

DIET (*continued*).

BUT, under all circumstances, make a firm stand against the POISON-HABIT. It is best to call things by their right names. The effect upon the animal economy of every stimulant is strictly that of a poison, and every poison may become a stimulant. There is no bane in the South American swamps, no virulent compound in the North American drug-stores—chemistry knows no deadliest poison—whose gradual and persistent obtrusion on the human organism will not create an unnatural craving after a repetition of the lethal dose, a morbid appetency in every way analogous to the hankering of the toper after his favorite

tipple. Swallow a tablespoonful of laudanum or a few grains of arsenious acid every night: at first your physical conscience protests by every means in its power; nausea, gripes, gastric spasms, and nervous headaches warn you again and again; the struggle of the digestive organs against the fell intruder convulses your whole system. But you continue the dose, and Nature, true to her highest law to preserve life at any price, finally adapts herself to an abnormal condition—adapts your system to the poison at whatever cost of health, strength, and happiness. Your body becomes an opium-machine, an arsenic-mill, a physiological engine moved by poison, and performing its vital functions only under the spur of the unnatural stimulus. But by and by the jaded system fails to respond to the spur, your strength gives way, and, alarmed at the symptoms of rapid *deliquium*, you resolve to remedy the evil by removing the cause. You try to renounce stimulation, and rely once more on the unaided strength of the *vis vitæ*. But that strength is almost exhausted. The oil that should have fed the flame of life has been wasted on a health-consuming fire. Before you can regain strength and happiness, your system must *readapt* itself to the normal condition, and the difficulty of that rearrangement will be proportioned to the degree of the present disarrangement; the further you have strayed from Nature, the longer it will take you to retrace your steps. Still, it is always the best plan to make your way back somehow or other, for, if you resign yourself to your fate, it will soon confront you with another and greater difficulty. Before long the poison-fiend will demand a larger fee; you have to increase the dose. The "delightful and exhilarating stimulant" has palled, the *quantum* has now to be doubled to pay the blue-devils off, and to the majority of their distracted victims that seems the best, because the shortest, road to peace. Restimulation really seems to alleviate the effects of the poison-habit for a time. The anguish always returns, and always with increased strength, as a fire, smothered for a moment with *fuel*, will soon break forth again with a fiercer flame.

By these symptoms the disease of the poison-habit may be identified in all its disguises, for the self-deception of the poor lady who seeks relief in a cup of the same strong tea that has caused her sick-headache is absolutely analogous to that of the pothouse sot who hopes to drown his care in the source of all his misery, or of the frenzied opium-eater who tries to exorcise a legion of fiends with the aid of Beelzebub. There are few accessible poisons which are not somewhere abused for the purpose of intoxication: the Guatemala Indians fuddle with hemlock-sap, the Peruvians with *coca*, the Tartars with fermented mare's milk, the Algerians with hasheesh; but, wherever men have dealings with the "fiend that steals away their brains," there are always Ancient Iagos who mistake him for a "good familiar creature," till he steals their health and wealth as well as their wits. Their woes are not the penalty of their persistent blindness, but of their first open-

eyed transgression. There is a Spanish proverb to the effect that it is easier to keep the devil out than to turn him out, and many dupes of the Good Familiar would actually think it an ingratitude to turn him off; but they should have known better than to admit him when he presented himself with horns and claws. To a normal taste every poison is abhorrent, and with the rarest exceptions the degree of the repulsiveness is proportioned to that of the virulence. In the mouth of a healthy child, rum is a liquid fire; beer, an emetic; tea and coffee, bitter decoctions; tobacco-fumes revolt the stomach of the non-*habitué*. Only blind deference to the example of his elders will induce a boy to accustom himself to such abominations; if he were left to the guidance of his natural instincts, intoxication would be anything but an insidious vice.

With all its ramifications, the poison-habit is a upas-tree which has polluted the well-springs and tainted the very atmosphere of our social life. The woe which the human race owes to alcohol alone is so far beyond description that I will here only record my belief that its total interdiction will form the first commandment in the decalogue of the future. The power of prejudice has its limits. No man, possessed of a vestige of common sense, can read the scientific literature that has accumulated upon the subject, and doubt that even the moderate use of distilled liquors as a beverage amply justifies the belief in the existence of unqualified evils. The effects of tea and coffee drinking are also well understood, but I must call attention to an often overlooked though most important feature of the habit—its progressiveness. The original moderate *quantum* soon palls, and it is this craving of the system *for the same degree of stimulation* which leads us to Johnsonian excesses or to the adoption of a stronger stimulant. Men generally prefer the latter alternative. Coffee, tea, and tobacco pave the way to opium in the East and to alcohol in the West. The same holds true of pungent spices. Pepper and mustard form the vanguard of the poison-fiend. They inflame the liver, produce a morbid irritability of the stomach, cause numerous functional derangements by impeding the process of assimilation, and thus become auxiliary in expediting the development of the poison-habit. Whatever irritates the digestive organs or unusually exhausts the vital forces tends to the same effect. Besides, they blunt the susceptibility of the gustatory nerves, and thus diminish our enjoyment of the simple viands that should form our daily food. In trying to heighten that enjoyment, the surfeited gastronome defeats his own purpose: all sweetmeats pall; the most appetizing dishes he values only as a foil to his caustic condiments, like the Austrian peddler who trudges through the flower-leas of the Alpenland in a cloud of nicotine, and to whom the divine afflatus of the morning wind is only so much draught for his tobacco-pipe.

With a single and not quite explained exception, man is the only animal that resorts to stimulation: a few ruminant mammals—cows,

sheep, and deer—pay an occasional visit to the next salt-lick. The carnivora digest their meat without salt; our next relatives, the frugivorous four-handers, detest it. Not one of the countless tonics, cordials, stimulants, pickles, and spices, which have become household necessities of modern civilization, is ever touched by animals in a state of nature. A famished wolf would shrink from a "deviled gizzard." To children and frugivorous animals our pickles and pepper-sauces are, on the whole, more offensive than meat, and therefore, probably more injurious. To savages, too. In the summer of 1875 I stood one evening near the quartermaster's office at Fort Wingate, New Mexico, when two Kiowa Indians applied for permission to water their famished horses at the Government cistern, offering to accept that boon in part payment of a load of brushwood which they proposed to haul from the neighboring *chaparral*. The fellows looked thirsty and hungry themselves, and, while the quartermaster ratified the wood-bargain, one of the officers sent to his company quarters for a lunch of such comestibles as the cooks might have on hand at that time of the day. A trayful of "Government grub" was deposited on the adjacent cord-wood platform, and the Indios pitched in with the peculiar appetite of carnivorous nomads. A yard of commissary sausage was accepted as a tough variety of jerked beef; yeasted and branless bread disappeared in quantities that would have confirmed Dr. Graham's belief in natural depravity; they sipped the cold coffee and eyed it with a gleam of suspicion, but were reconciled by the discovery of the saccharine sediment, and the cook was just going to replenish their cups when the senior Kiowa helped himself to a vinegar pickle, which he probably mistook for some sort of an off-color sugar-plum. He tasted it, rose to his feet, and dashed the plate down with a muttered execration, and then clutched the prop of the platform to master his rising fury. Explanations followed, and a pound of brown sugar was accepted as a peace-offering, but the children of Nature left the post under the impression that they had been the victims of a heartless practical joke. "D—n their breechless souls, they don't know what's good for them!" was the cook's comment, which I should endorse if his guests had been in need of a blister. A slice of a peppered and allspiced vinegar pickle will blister your skin as quick as a plaster of Spanish flies. The lady-friends of Dio Lewis have promised us an "Art of Cookery for Total Abstainers," and, if the book should correspond to the title, I would suggest a motto: "No spice but hunger; no stimulant but exercise."

By avoiding pungent condiments we also obviate the *principal cause of gluttony*. It is well known that the admirers of lager-beer do not drink it for the sake of its nutritive properties, but as a medium of stimulation, and I hold that nine out of ten gluttons swallow their peppered *ragoûts* for the same purpose. Only natural appetites have natural limits. Two quarts of water will satisfy the normal thirst of

a giant, two pounds of dates his hunger after a two days' fast. But the beer-drinker swills till he runs over, and the glutton stuffs himself till the oppression of his chest threatens him with suffocation. Their unnatural appetite has no limits but those of their abdominal capacity. *Poison-hunger* would be a better word than appetite. What they really want is alcohol and hot spices, and, being unable to swallow them "straight," the one takes a bucketful of swill, the other a potful of grease into the bargain.

But gluttony has one other cause—involuntary cramming. Fond mothers often surfeit their babies till they sputter and spew, and it is not less wrong to force a child to eat any particular kind of food against his grain—in disregard of a natural antipathy. Such aversions are allied to the feeling of repletion by which Nature warns the eater to desist, and, if this warning is persistently disregarded, the monitory instinct finally suspends its function; overeating becomes a morbid habit, our system has adapted itself to the abnormal condition, and every deviation from the new routine produces the same feeling of distress which shackles the rum-drinker to his unnatural practice. Avoid pungent spices, do not cram your children against their will, and never fear that natural aliments will tempt them to excess. But I should add here that of absolutely innocuous food—ripe food and simple farinaceous preparations—a larger quantity than is commonly imagined can be habitually taken with perfect freedom from injurious consequences. On the Upper Rhine they have *Trauben-Curen*—sanitaria where people are fed almost exclusively on ripe grapes in order to purify their blood. The grapes generally used for this purpose are of the variety known as Muskateller, with big, honey-sweet berries of a most enticing flavor. "Doesn't such physic tempt your patients?" I asked the manager of a famous Trauben-Cure; "don't they dose themselves to a damaging extent?" His answer surprised me. "Damaging? Yes, sir," said he, "they damage my pocket, some of them do, though I charge them three florins a day, lodgers five. They can not damage *themselves* by eating Muskateller."

Never stint the supply of fresh drinking-water. The danger of water-drinking in warm weather has been grossly exaggerated. Cold water and cold air are the two scapegoats that have to bear the burden of our besetting sins. There is, indeed, something preposterous in the idea that Nature would punish us for indulging a natural appetite to its full extent. Sheep that have been fed on dry corn-husks all winter sometimes break into a clover-field and eat till they burst; but who ever heard of a dyspeptic bear, or of an elk prostrated by a fit of gastric spasms? And yet we need not doubt that wild animals eat while their appetite lasts. If we lock them up and deprive them of their wonted exercise, their appetite, too, diminishes. In short, as long as we confine ourselves to our proper diet, our stomachs never call for more than we can digest. There are things that have to be eaten

in homœopathic doses to prevent surfeit, but respecting such stuff (Limburger, caviare, etc., I would say, as of spices and alcohol), abstinence is better than temperance. In convivial neighborhoods sporadic cases of surfeit are almost as unavoidable as Christmas dinners and school picnics; but their effects are as transient as their causes. For children, a nearly infallible peptic corrective is a *fast day passed in cheerful out-door exercise.* By a curious law of periodicity, the mind will stray to the dining-room when the wonted meal-time comes around, even if genuine appetite does not return with that hour, but fishing, hunting, and ball-playing divert our thoughts from such channels, and, returning late in the evening from a good day's sport, the periodicity of bedroom-thoughts, aided by fatigue, overcomes the latent craving for food without the least effort. Try the experiment.

Want of appetite is not always a morbid symptom, nor even a sign of imperfect digestion. Nature may have found it necessary to muster all the energies of our system for some special purpose, momentarily of paramount importance. Organic changes and repairs, teething, pleuritic epurations, and the external elimination of bad humors (boils, etc.), are often attended with a temporary suspension of the alimentary process. The instinct of domestic animals thus generally counteracts the influence of abnormal circumstances. As a rule, it is always the safest plan to give Nature her own way, and was thus proved even in the extreme cases of more than one *bona fide* fasting girl, whose system, for recondite reasons of its own, preferred to subsist on air for weeks and months together.

In regard to the quality of food, too, there are intuitive dislikes which should not be disregarded, because they can not always be accounted for. I do not say *likes and* dislikes; a child's whimsical desire to treat innutritious or injurious substances as comestibles should certainly not be encouraged as long as its hunger can be appeased with less suspicious aliments. For it is a curious fact that *all* unnatural practices—the eating of indigestible matter as well as of poisons—are apt to excite a morbid appetency akin to the stimulant habit. The human stomach can be accustomed to the most preposterous things. The Otomacs, of South America, whose forefathers in times of scarcity may have filled their bellies with loam, are now afflicted with a national *penchant* for swallowing inorganic substances. In New Caledonia, *habitués* often eat as much as two pounds of ferruginous clay a day, and a similar stuff is sold in the markets of Bolivia, and finds eager purchasers, even when better comestibles are cheaper. Professor Ehrenberg procured a sample of this clay which was supposed to contain organic admixtures or some kind of fat; but his analysis proved that it consists of talc, mica, and a little oxide of iron. According to Malte-Brun, the Lisbon lazzaroni chew all day long the insipid, leathery kernels of the carob-bean (*Mimosa silica*), and the most popular "chewing-gum" is said to be composed chiefly (not entirely, I

hope) of resin, paraffine, and triturated caoutchouc! Still, Ehrenberg's analysis makes stranger things credible. I do not doubt that a man might contract a habit of swallowing a couple of slate-pencils or a dime's worth of shoe-strings every morning.

But an innate *repugnance* to a special dish, or even to a special class of aliments, may be indulged very cheaply, and certainly very safely, as long as there are other available substances of the same nutritive value. Abnormal antipathies may indicate constitutional abnormities, and among the curious cases on record there are some which clearly preclude the idea of imaginative influences. I knew a Belgian soldier on whom common salt, in any combination, and in any dose exceeding ten pennyweights, acted as a drastic poison, and thousands of Hindoos can not taste animal food without vomiting. Similar effects have obliged individuals to abstain from onions, sage, parsnips, and even from Irish potatoes. Dr. Pereira mentions the case of an English boy who had an incurable aversion to mutton: "He could not eat mutton in any form. The peculiarity was supposed to be owing to caprice, but the mutton was repeatedly disguised and given to him unknown; but uniformly with the same result of producing violent vomiting and diarrhœa. And from the severity of the effects, which were in fact those of a virulent poison, there can be little doubt that, if the use of mutton had been persisted in, it would soon have destroyed the life of the individual."*

It may be considered as a suggestive circumstance that the great plurality of such instinctive aversions relate either to stimulants or to some kind of animal food. To one person whose stomach can not bear bread or apples, we shall find a thousand with an invincible repugnance to pork, coffee, and pungent condiments. It is also certain that, by voluntary abstinence from all such things, the vigor of the alimentary organs can be considerably increased. The Danish sailors whom the Dey of Algiers had fed on barley and dates for a couple of months, found that after that they "could digest almost anything."†

By adopting an absolutely non-stimulating, chiefly vegetable diet, combined with active exercise in open air, the most dyspeptic glutton can cure himself in the course of a single season, and by the same means every boarding-school might become a dietetic sanitarium. The following list of hygenic *menus* is arranged in the order of their digestibility and wholesomeness:

Milk, bread, and fruit.—Eggs (raw or whipped), bread and honey.—Boiled eggs, bread, and apples (ancient Rome).—Bread and butter, rice-pudding, with sugar and fresh milk.—Corn-bread or roasted chestnuts, butter, honey, and grapes (the usual diet of the long-lived Corsican mountaineers).—Fish, butter, oatmeal-porridge, and fresh milk (Danish Islands).—Pancakes, honey or new molasses, poached eggs,

* Pereira, "Treatise on Food and Diet," p. 242.

† Wodderstadt, "On Yellow Fever," p. 72.

boiled milk, and bread-pudding.—Vegetable soups, baked beans, potatoes (baked or mashed), butter, biscuits, and apple-dumplings.

GENERAL RULES.—Avoid stimulants; alcoholic and narcotic drinks, tobacco, and all pungent spices; be sparing in the use of animal food, especially in summer-time; in midsummer eat fruit with every meal; let unprepared food (fresh milk, fruits, etc.) form a part of your daily fare; of unprepared aliments as well as of all unspiced viands, the most palatable are the most wholesome; eat slowly and masticate your food; never eat if you have no appetite; and finish your last meal three hours before bedtime.

As a dessert I will add a few of my favorite dietetic aphorisms: An hour of exercise to every pound of food.—We are not nourished by what we eat, but by what we digest.—Every hour you steal from digestion will be reclaimed by indigestion.—Beware of the wrath of a patient stomach!—He who controls his appetite in regard to the quality of his food may safely indulge it in regard to quantity.—The oftener you eat, the oftener you will repent it.—Dyspepsia is a poor pedestrian; walk at the rate of four miles an hour, and you will soon leave her behind.—The road to the rum-cellar leads through the coffee-house.—Abstinence from *all* stimulants, only, is easier than temperance.—There are worthier objects of charity than famine-stricken nations that send their breadstuffs to the distillery.—An egg is worth a pound of meat; a milch-cow, seven stall-fed oxen.—Sleep is sweeter after a fast-day than after a feast-day.—For every meal you lose you gain a better.

How often should we eat is still a mooted question. For men in a state of nature the answer would be simple enough; but, considering our present artificial modes of life, I must say that the choice of fixed hours is less important than the observation of the following rule: *Never eat till you have leisure to digest.* For digestion requires leisure; we can not assimilate our food while the functional energy of our system is engrossed by other occupations. After a hearty feed, animals retire to a quiet hiding-place; and the "after-dinner laziness," the plea of our system for rest, should admonish us to imitate their example. The idea that exercise after dinner promotes digestion is a mischievous fallacy; Jules Virey settled that question by a cruel but conclusive experiment. He selected two curs of the same size, age and general *physique*, made them keep a fast-day and treated them the next morning to a square meal of potato-chips and cubes of fat mutton, but, as soon as one of them had eaten his fill, he made the other stop too, to make sure that they had both consumed the same quantity. Dog No. 1 was then confined in a comfortable kennel, while No. 2 had to run after the doctor's coach, not at a breathless rate of speed, but at a fair, brisk trot, for two hours and a half. As soon as they got home, the coach-dog and his comrade were slain and dissected: the kennel-dog had completely digested his meal, while the

chips and cubes in the coach-dog's stomach had not changed their form at all; the process of assimilation had not even begun! Railroad laborers, who bolt their dinner during a short interval of hard work, might as well pass their recess in a hammock; instead of strengthening them, their dinner will only oppress them, till it is digested, together with their supper, in the cool of the evening. In a manner essentially similar, mental activity tends to hinder the digestive process for a considerable time; and I believe, more especially, the digestion of the very substances that are often selected as brain-food *par excellence*. Even after a fashionable dinner of six or seven courses (*curses*, Dr. Abernethy used to call them), two hours of absolute rest will set our wits a-work again; but, if that time be passed behind a double-entry ledger, a feeling of lassitude, often combined with an almost resistless somnolence, will advise the brain-worker that his vital energy is needed for other purposes. "I could eat with more comfort if it wasn't for the consciousness of having to hurry back to my drudgery," I heard a poor class-teacher say, and the same consciousness embitters the noonday-meal of millions of school-children and overworked clerks.

Andrew Combe, M. D., informs us that a century ago the tradesmen of Edinburgh used to indulge in a "nooning," a general suspension of business for two hours, in the middle of the day. But an hour or so was thus probably spent in going home and back, dressing, etc., and half an hour at the meal itself; so that, after all, only thirty minutes remained for digestion; and, considering the anachronism of that nooning practice, the best plan, on the whole, would seem to be a general return to the method of the ancient Romans, who postponed their principal meal till their day's work was done. It would be an insult to common sense and humanity to doubt that the eight-hour system will ultimately prevail, and, where it has been already adopted, I can see no reason why mechanics could not arrange to finish their day's job at 4 P. M. Schools should always close at four. Bankers and government clerks often get home before that time, and competitive shopkeepers might carry on their business by relays. At half-past four, or, say, five o'clock, the *cœna domestica* might begin, conclude before six; then *dolce far niente*, pleasant conversation, and four blessed hours for digestion.

But that principal meal should be the last. It is an important rule that we should digest our food thoroughly before we replenish the stomach. To counteract the effects of overeating, the gluttons of ancient Rome used emetics, the Parisian gastronomes stimulants. Dr. Alcott wants us to "leave off hungry"; the exponents of the movement-cure prescribe a certain system of gymnastic evolutions before and after dinner. But there is a better plan: *Lengthen the interval between meals.* Two meals a day are enough, perhaps more than enough, though we can accustom ourselves to swallow (not digest) five

or six. It all depends on training, and in no other respect is the human system so plastic to the influence of habit. The Rev. Mr. Moffat tells us that the Gonaque Hottentots are noways incommoded by a five days' fast, and get old on an average of four meals a week. The Greeks and Romans during the prime of their republics contented themselves with one meal a day; Claude Bernard recommends two, but his countrymen generally eat three; their German neighbors four; the East-Germans even five: breakfast, second breakfast (*zweites Frühstück*), dinner, *Vesperbrot*, and supper, to which supper the Vienna burghers actually superadd a *Nacht-bissel*—a "night-lunch," of cold potato-salad with bread and *Wurst*, and often with a mug of beer—"for the stomach's sake"! I get along comfortably with a meal and a half; so does my grand-uncle, an octogenarian, who still masticates his bread with a full set of unbought teeth. Two, or one and two halves, should be enough for any man. The lightest breakfast is the best—buckwheat-cakes with a little honey or apple-butter, and a glass of milk, or a cup of chocolate, if you must take "something warm." Chocolate possesses nutritive properties, which tea and coffee *per se* are totally devoid of. I never use it, but I believe it is non-stimulating. Or chew a crust of stale bread, the best dentifrice and a useful absorbent, good for acidity of the stomach. At noon take a glass of milk and a couple of biscuits, or in summer a couple of ripe pears or peaches; they will keep you cool during the post-meridian heat and do you more good than a cocktail lunch. Never keep a pocket-flask. Don't stay with flagons; better comfort with apples, if you can not wait till five. School-children should pass their recess on the playground. A biscuit and a pocketful of apples will satisfy the temporary demands of the stomach; and, if they have munched up their comestibles in the course of the morning, as boys are apt to do, they will find it far easier to forego their noonday lunch altogether than to resist the insidious somnolence which would dull their wits after a regular dinner, and often makes the afternoon lesson a protracted struggle between nature and duty.

But at the principal meal they should eat their fill. Let them pitch in, without fear of dangerous consequences—unless your landlord charges by the plateful. Children, like monkeys, have a way of dallying with their food if they are full—picking a crumb here and there, or mumbling their apples without using their teeth. Make them get up if you notice such symptoms, or, better, entice them away by improvising some out-door or up-stairs amusement. But I repeat, never press them to eat—for principle's sake—not even your young visitors; they are not likely to go to bed hungry if your *menu* comprises such items as baked apples or bread-pudding and sweet milk.

Jean Jacques Rousseau holds that intemperate habits are mostly acquired in early boyhood, when blind deference to social precedents is apt to overcome our natural antipathies, and that those who have

passed that period in safety have generally escaped the danger of temptation. The same holds good of other dietetic abuses. If a child's natural aversion to vice has never been willfully perverted, the time will come when his welfare may be intrusted to the safe-keeping of his protective instincts. You need not fear that he will swerve from the path of health when his simple habits, sanctioned by Nature and inclination, have acquired the additional strength of long practice. When the age of blind deference is passed, vice is generally too unattractive to be very dangerous. "Why make yourself the slave of such a degrading habit?" says Count Zinzendorf, in his "Hirtenbrief"; "it is so easy never to begin!" I go further. I say it is difficult to begin. Nature is not neutral on a point of such importance. Between virtue and vice she has erected a bulwark which she intended to last from birth to death. We need not strengthen that bulwark. We need not guard it with anxious care; it will stand the ordinary wear and tear of life. All we have to do is to save ourselves the extraordinary trouble of breaking it down.

Pure joys never pall; uniformity is uniform happiness if the even tenor of our way is the way of Nature. And Nature herself will guide our steps if the exigence of abnormal circumstances should require a deviation from the beaten path. Remedial instincts are not confined to the lower animals; man has his full share of them; the self-regulating power of the human system is as wonderful in the variety as in the simplicity of its resources. Have you ever observed the weather-wisdom of the black bindweed?—how its flowers open to the morning sun and close at the approach of the noontide glare; how its tendrils expand their spirals in a calm, but contract and cling, as with hands, to their support when the storm-wind sweeps the woods? With the same certainty our dietetic instincts respond to the varying demands of our daily life. Without the aid of art, without the assistance of our own experience, they even adapt themselves to the exigencies of our abnormal social conditions, and our interference alone often prevents them from counteracting the tendency of dire abuses.

Summer brings no repose to the slaves of Mammon, but dull headaches and the stomach's imperative demand for rest convince even the unwilling that intricate arithmetical problems and 90° Fahr. are incompatible with digestion; and I ascribe it to the logic of those gastric arguments that bankers and brokers now close their shops at 3 P. M.; and that business men generally avoid repletion in the middle of the day. "Cheese is gold in the morning, silver at noon, and lead at night," says a mediæval proverb; but the effects of those horrid cheese and porter breakfasts of Queen Anne's time satisfied our grandams that rotten curd and fermented (i. e., putrid) barley-broth are always lead, except to those who employ the hygienic philosopher's stone—active and long-continued out-door exercise. After recovery from an exhausting sickness—especially if you decide to promote that recovery by

throwing physic to the dogs—the demands of your stomach will often become exorbitant, but only apparently so; your system wants to repair the waste of the disease. Never fear that "the digestive organs are too feeble yet," etc.; those organs will keep their promise, unless you break yours by resuming medication. Have you eaten more than the wants of your system require? Your appetite will not respond to your invitation at the next meal. Take the hint—wait. Do not increase the troubles of your stomach by mordant spices and alcohol. In the sultry dog-days your system craves a surcease of greasy *ragoûts* and yearns for something refreshing—sherbet or cool fruit. Get a watermelon. "But isn't the yellow fever in town? Quack, Quinine, and other leading physicians, agree that one must take a course of antiseptics, and avoid vegetables at such seasons." Don't believe them; Nature knows better. Fruit is a better antiseptic than fusel poison and wormwood. The frugivorous Mexican survives where the beef-eating stranger dies in spite of his bitters. If sailors have been surfeited with salt meat, their craving after lemon-juice or fresh fruit becomes more urgent from day to day; the surcharge of their organism with saline matter requires a neutralizing acid. A single meal of salt herring excites merely thirst; common water is yet sufficient to dilute the ingesta and eliminate the salt. Vegetable substances that consist chiefly of starch and water supply the wants of our organism less completely than those that contain an admixture of gluten, albumen, and fat; and, if we restrict our diet to the first-named class of aliments, our system announces the deficit by means of our senses; without such complements as milk, sugar, or fat, rice-bread is more insipid than bread from unbolted wheat-flour.

All dietetic needs of our body thus announce themselves in a versatile language of their own, and he who has learned to interpret that language, nor willfully disregards its just appeals, may avoid all digestive disorders—not by fasting if he is hungry or forcing food upon his protesting stomach, not by convulsing his bowels with nauseous drugs, but by quietly following the guidance of his instincts.

Nature's health laws are simple. The road to health and happiness is not the labyrinthine maze described by our medical mystagogues. In perusing their dietetic codes one is fairly bewildered by a mass of incongruous precepts and prescriptions, laborious compromises between old and new theories, arbitrary rules, and illogical exceptions, anti-natural restrictions and anti-natural remedies. Their views of the constitution of man suggest the King of Aragon's remark about the cycles and epicycles of the Ptolemaic system: "It strikes me the Creator might have arranged this business in a simpler way."

All normal things are good, all evil is abnormal, is an axiom which has been almost reversed in the principle of our orthodox health theories, for many of our physical educators still hold to the cardinal error of their spiritual colleagues, who consider depravity and wretchedness

as the normal condition of man, and happiness as the reward of a self-abhorring suppression of all natural desires and of a blind confidence in the efficacy of an abnormal and mysterious remedy—nay, who despise Earth herself as a "vale of tears," and life as a disease whose only cure is death, whose only anodyne a dream of a supernatural elysium. It is time to awake from that dream. It is time to open our eyes to the well-springs of life and happiness which the bounty of our Mother Earth sends forth in such abundance, and which man might enjoy with all his fellow-creatures if his perversity had not turned them into sources of misery and death. Instead of insulting our Maker by the doctrine of innate depravity, we should learn to distinguish the voice of our natural instincts from the cravings of a morbid appetency. We should try to restore life to its original purity and healthfulness instead of despising it and looking for happiness beyond the grave.

But the deluge of mediæval superstitions is fast assuaging, and many a submerged truth has reappeared like a bequest of a former and better world, and now stands as a way-mark on the road to a true Science of Life. We have rediscovered the truth that the weal and woe of earth are not distributed by the caprices of a mysterious Fate, but that they follow as sure effects upon ascertainable causes. Our best thinkers have ceased to doubt that man can work out his own destiny, that the Creator has made us the keepers of our own happiness on conditions which he never violates; that he has attached pleasure to every right act, and pain to every wrong, that he fulfills the promises of our yearnings, and never permits us to sin unwarned. We have at last begun to realize the fact that the physical laws of God find an echo in the voice of our innate monitor, and only an hereditary mistrust in our instincts makes us still hesitate to commit ourselves to its guidance. But experience will overcome that prejudice by and by; duty and inclination will go hand in hand, and the result will justify our trust in the wisdom and benevolence of Nature.

HORSES AND THEIR FEET.

By Sir GEORGE W. COX.

IF we say that of all brute animals none is more valuable to man than the horse, and that the neglect of any means which may promote and insure his welfare and efficiency is a blunder not easily distinguishable from crime, we may fairly be charged with uttering truisms. If we urge that this value is not recognized as it should be, and that this neglect is miserably common, we may still be accused of wasting breath on statements which no one would think of calling into

question. Every one, we may be told, is well aware that the management of horses is very faulty, that their lives are shortened by the ignorance of those who have charge of them rather than by any wanton cruelty, and that they are rendered practically useless long before their existence is brought to an end. To the plea that the same, or much the same, things may be said of men as of horses, we may answer that the blame must be apportioned to the degree of carelessness with which evils affecting either men or horses are allowed to go on unchecked, or are foolishly dealt with; nor can failures to improve the condition of mankind furnish a reason for refusing to do what may improve the condition of horses. Our duty ought to be discharged at all costs and under all circumstances; but a man must have risen far above the average of his fellows if he feels no relief when his duty coincides with his interest. Something is gained by the mere pointing out of this agreement, wherever it exists; and we must remember that, if a vast amount of human wretchedness is the direct result of willful and wanton perversity, we can meet with no such resistance on the part of brute beasts. With regard to these we have only to see what the evils are; and the blame is ours, and ours alone, if we fail to apply the remedy, when the remedy, if applied, must be successful. In the case of the horse, unhappily, we do not realize the extent of the mischief, and seldom, perhaps never, fix our minds on its cause or causes. Yet the facts, even when reduced within limits which none will venture to dispute, are sufficiently startling.

The number of horses in the United Kingdom has been estimated at rather more than two millions and a quarter, and their average value can scarcely be set down at less than thirty pounds. Their collective value, therefore, falls little short of £68,000,000. That the nation incurs a loss if this sum is spent quicker than it needs to be is a self-evident proposition; that it is so spent is certain, if horses on an average become useless at a time when they ought still to be in full vigor. On this point few will be disposed to challenge the verdict of Mr. W. Douglas, late veterinary surgeon in the Tenth Hussars, who tells us that a horse should live from thirty-five to forty years, and live actively and usefully during three fourths of this period. "All authorities,' he says, "now admit that animals should live five times as long as it takes them to reach maturity. A dog, which is at its full growth when between two and three years old, is very aged at twelve years. Horses do not, unless their growth is forced, reach their full prime until they are seven or eight years old, which by the same law leaves them to live some thirty years longer. When these facts are kept in mind, together with these other facts that three fourths of our horses die or are destroyed under twelve years old, that horses are termed aged at six [he should have said eight], old at ten, very old when double that number of years, and that few of them but are laid up from work a dozen times a year, . . . the viciousness of a system

which entails such misery and destruction of life can not be too strongly commented upon." If we take the age of three years as that at which horses begin to work, and twelve as that at which they are worn out, it follows that the period of their efficiency is shorter by at least fourteen years than it should be. In other words, the nation has to buy three horses when it ought to buy only one, and thus upward of £200,000,000 are spent every twenty-one years in the purchase of horses when £68,000,000 ought to suffice. The loss, therefore, to the nation is at least £135,000,000 in twenty-one years.

If this were all, the question would surely be most serious ; but it is not all. Unless the facts thus far stated can be set aside, our horses work on the average seven or eight years ; but how do they work ? The collective experience of the country will answer that the work is done at the cost of frequent interruptions, and with an amount of discomfort and pain which often becomes agony. It is easy to say that much of the evil must be laid to the charge of grooms and stable-men; and perhaps the censures dealt out to these men are not undeserved. They are, at least, outspoken. In the last century Lord Pembroke spoke of grooms as being "generally the worst informed of all persons living." "No other servant," says Mr. Mayhew, "possesses such power, and no domestic more abuses his position. It is impossible to amend the regulation of any modern stable without removing some of this calling, or overthrowing some of the abuses with a perpetuation of which the stable servant is directly involved." In this state of things the most humane of masters becomes, he adds, an unconscious tyrant to the brute which serves him so well. It is a miserable fact that grooms on their own responsibility are in the habit of administering secretly to horses medicines the cost of which they pay themselves. It may fairly be said that in every case the remedy is ill-judged, and creates worse mischief than that which it is designed to remove. Among these medicines, arsenic, antimony, and niter seem to be the favorites ; but the list of remedies is not ended with these. The experience of ages, if it has failed to do more, has impressed on them the fact that the chief source of the sufferings of horses is to be found in the foot. The suspicion that the foot is not treated rightly by the traditionary method never enters their minds ; and they deal with the limb not from a knowledge of its anatomy, structure, and purpose, but in accordance with the popular notions, which are, in plain speech, outrageously absurd. In profound ignorance that the hoof is porous, they apply hoof-ointments, which answer to cement plastered on a wall. If these were in constant use, Mr. Douglas asserts emphatically that not a morsel of sound horn would remain at the end of six months on the horses, and shoeing would become an impossibility. If the groom be told that he is thus preventing the internal moisture from reaching the outer surface and the air from circulating inward, his only answer is an incredulous laugh. His conviction is that the hoof should not come

into contact with hard material, and that the horse can be best fitted for his work by having his feet smeared with tar, beeswax, or tallow, and by resting always on a heap of litter in the stable. It would be of little use to cite Lord Pembroke as declaring that "the constant use of litter makes the feet tender and causes swelled legs; moreover, it renders the animals delicate. Swelled legs may be frequently reduced to their proper natural size by taking away the litter only, which, in some stables, where ignorant grooms and farriers govern, would be a great saving of bleeding and physic, besides straw. . . . I have seen," he adds, "by repeated experiments, legs swell and unswell by leaving litter or taking it away, like mercury in a weather-glass"; and his experience is confirmed by the general condition of troopers' horses, in contrast with those of their officers, which are bedded down all day.

But, if there are evils for which grooms are in large measure directly responsible and the abolition of which they would beyond doubt stoutly resist, there are others in which masters are not less blameworthy than their men, and from which the public generally as well as the animals are constant sufferers. The work of the horse is that of dragging and carrying; and the aim of the owner should be the accomplishment of this work with the utmost possible sureness and with the fewest accidents. Serious and fatal injuries may be the result of stumblings and slippings not less than of actual falls; and the premature wearing out of horses by excessive straining of their sinews and muscles is a direct pecuniary loss to the owners, although few of them seem to realize the true significance of the fact. These evils are to be seen everywhere, and they affect horses kept for the purpose of pleasure and ostentation almost as much as those which spend their days in a round of monotonous drudgery. A horse should not be obliged to work in going down a hill; but, in fact, they are subject to the severest strain just when they ought to have none, if they are harnessed to springless carts or wagons without breaks. Farm-horses suffer with terrible severity from this cause; but the horses used in carrying trades and by railway companies undergo a more cruel ordeal. Improvements in the break-power of wagons used on roads, which might greatly lessen the mischief, are not made, and hence the horses are seldom free from diseases more or less serious, which may be traced directly to constant slipping and shaking over slippery pavements. Among ignorant owners, blind to their own interests, there is an impression that "the work which kills one horse will bring in money enough to buy another"; but experience has sufficiently shown the fallacy of this theory, whether the overtaxed slave be a horse or a human being. In towns and cities the roads are, and must be, paved, and the pavings at present are variously of stone, wood, or asphalt, where the road is not macadamized. These pavements have, it would seem, each its own peculiar dangers for the horses which use them; and each has thus become a fruitful source of controversy. If any

one method be likely to supersede the rest, the victory will probably be for the asphalt; but horses are found to slip seriously upon it, and the falls so caused are, we are told, of a graver kind than those on pavements of other sorts. All the proprietors of cabs, omnibuses, and railway-vans have, it is said, protested in a body against its use, but scarcely, it would seem, to good purpose. Fresh contracts have been signed for pavements of asphalt, and others will probably follow. In the mean while horses have to pass, perhaps in a single morning, from macadamized roads to roads paved with asphalt, wood, or stone—in other words, over roads made of widely differing materials, which call in each case for a different action of the foot. On the other hand, the hoof is supposed to be protected by shoes, the varieties of which are legion; and thus the controversy has been brought to a singular issue. On one side it is urged that there should be a uniform system of paving enforced on all towns, so that horses should no longer pass from a less slippery road to one that is more slippery; on the other the contention is that the true remedy lies not in uniformity of paving, but in the discovery of a shoe which shall effectually prevent the horse from slipping anywhere. The former alternative is visionary; the latter has been, and perhaps it may be said still is, the object aimed at by some who have a thorough acquaintance with the structure of the horse, and the most disinterested wish to promote his welfare. We may therefore safely pay no heed to the lamentations of those who believe that "the difficulty in riding or driving through the London streets arises from the variety of the pavements in use," and that, "if we had a uniform kind of pavement, a shoe for universal use would be quickly invented." We may please ourselves with fancying that "the ingenuity of man would devise horseshoes to travel over glass, were glass the only pavement in use." The main question is, whether mankind after all has not been forestalled in this invention; and it is absolutely certain that those who have labored most conscientiously to improve the shoeing of horses have striven especially to secure for them the power of moving safely over materials of many kinds. These men have been convinced that the traditional methods overload the foot of the horse with iron, and that the modes of fastening on this iron interfere with, if not altogether obstruct, the processes of nature. The efforts of all have been directed toward diminishing the weight of iron, and this has led them to the conclusion that the less the natural foot is interfered with the better. M. la Fosse thus inferred that one half of the ordinary shoe was unnecessary, and that nothing more was needed than a tip on the front half of the foot. Unfortunately, he directed that the heel should be pared, thus making it weaker, and he fastened on his tip, which had about six inches of iron in its entire length, with eight nails. He was thus "inserting wedges, amounting in the aggregate to from one to one and a half inch in thickness, in six inches of horn, thus squeezing it into the space of five or even four

inches, and killing it from the clinches downward and outward." It is strange that veterinary surgeons who have clearly comprehended the mischief thus caused have failed to draw the logical inference from their premises. Mr. Douglas was aware that the crust of the horse's foot resembles in its natural state a number of small tubes, bound together by a hardened, glue-like substance, and he compares it to a mitrailleuse gun with its many barrels soldered together. By his way of nailing, M. la Fosse was reducing the size of each tube by one sixth, or rather was entirely closing those nearest the nails and compressing those that lie half-way between each pair of nails. He was in this respect aggravating the mischief of the ordinary shoe, which commonly has seven nails ; and this insured dryness and brittleness of hoof. But the circulation of fluid through the pores of the hoof is not the only natural process which modern shoeing interferes with. In his work on the horse's foot, Mr. Miles illustrates the expansion and contraction which always take place in its natural state when it is set down on and lifted from the ground. The subject was a horse nine years old, which had the shoe removed for the purpose of the experiment. "The unshod foot was lifted up, and its contour traced with the greatest precision on a piece of board covered with paper. A similar board was then laid on the ground ; the same foot was then placed upon it, and the opposite foot held up while it was again traced. The result was that it had expanded one eighth part of an inch at the heel and quarters." Over two inches on each side of the center of the toe no expansion had taken place, the tracings showing that the expansion was only lateral. It would follow that a shoe intended to give full play to this process must be confined to the part where no expansion takes place ; but Mr. Miles adhered to the form of the ordinary shoe, although he reduced to three the number of nails by which it was fastened. The object of this process of expansion and contraction is to give the animal a firmer hold on the soil, and to enable him, where this is thick, slimy, or sticky, to withdraw the foot easily on contraction. This purpose is necessarily defeated when the whole foot is armed with iron.

No one has condemned the mischievous working of the existing system more strongly than Mr. Mayhew, who refuses to allow that the body of the horse was made stronger than his legs and feet, and holds that these, if left to themselves, must be adequate to the tasks imposed on them. In his belief, "it is among the foremost physiological truths, that Nature is a strict economist," and that "man has for ages labored to disarrange parts thus admirably adjusted. . . . No injury, no wrong, no cruelty, can be conceived, which barbarity has not inflicted on the most generous of man's many willing slaves." But, although he has thus seen "the folly of contending against those organizations which govern the universe," he still thought that the employment of some sort of shoe might not lie open to this charge. Shoes of some

sort may give to the horse the freedom which is essential for the health of the foot, although he insists that all the shoes thus far used are lamentable failures. "There are," he says, "many more pieces of iron curved, hollowed, raised, and indented than I have cared to enumerate. All, however, have failed to restore health to the hoof. Some by enforcing a change of position may for a time appear to mitigate the evil; but none can in the long run cure the disorder under which the hoof evidently suffers." Such language, it might be thought, could come only from one who had discarded the use of shoes altogether. All, however, that Mr. Mayhew has done, is to point the way to the road which he was not prepared to take. But the experience of Miles and Mayhew, La Fosse, Charlier, and Douglas, seems to lead by necessary logical inference to one conclusion only. If the working of the traditionary system leaves the horse a wreck almost before he has reached his prime, if the lessening of the weight of iron and of the number of nails used in fixing the iron has been followed by direct and important benefits in every instance, if even those who hold that a horse must be shod have discovered that that which they look on as a protection to the fore-feet is merely harmful to the hind-feet, is it possible to stifle the suspicion that this insignificant remnant of a system so fruitful in mischief may have no magic power, and, in short, that the horse may do just as well without them?

This conclusion has been courageously avowed and most ably enforced by a writer calling himself "Free Lance," in his recently published work on "Horses and Roads"; and, to say the least, it is time that the whole question should be fully and impartially considered. It affects the wealth of the nation, and on it depend both the usefulness and the comfort of a race of noble animals which are indispensable to our prosperity. The force of prejudice may be great, and a widespread traditional system may not be soon or easily overthrown; but it can not for a moment be supposed that Englishmen generally will assume with reference to it an attitude of unreasoning and obstinate antagonism. Fear probably will be found to supply a restraining motive more powerful than open ill will. Many who think that the new theory may look well enough on paper will doubt its value in practice, and will regard their own horses as exceptions to which it can not apply. With a strange ignorance of fact, they will insist that unshod horses may move safely over smooth and soft ground, but must fail when it is rugged, and hard, and stony, or will be oppressed by a vague dread that a horse which has gone well enough without shoes for six months may break down in the seventh. But even those who refuse to give up the practice of shoeing will yet acknowledge its faultiness, and wish that they could give it up without risk. To all such we need only say that if they have any regard for impartiality they are bound to consider the arguments and the facts on which the conclusions of "Free Lance" rest; and most assuredly they will find in

his pages nothing which they may charge with extravagance, rashness, and intolerance. They will not be told that unless they abandon the system of shoeing altogether they can effect no improvement in the present state of things, or even that they must hasten to change the old system for the new. On the contrary, they will find that they are again and again warned against imprudent haste, and are told that a vast amount of good may be achieved even if they never venture on leaving their horses' feet in a state of nature.

Of these arguments and facts it might be difficult to determine which are the most important and significant. Certain it is that our horses generally are afflicted with a multitude of diseases which seize on their legs and feet, and that lameness is everywhere a cause of constant complaint and of loss of time and money. The author is not speaking from theory or from book, but takes his stand on an experience obtained during a sojourn of many years in foreign countries, especially in America, where in the construction of railways and other public works he had to employ hundreds of horses and mules on tasks which taxed their capabilities to the utmost. In Mexico, Peru, Brazil, and elsewhere, he found that unshod horses were daily worked over roads of all kinds, carrying heavy packs from the interior down to the coast, the journey thither and back being often extended to several hundreds of miles, and that they accomplish these journeys without ever wearing out their hoofs; and the roads in these countries, where they exist at all, are neither softer nor smoother than those of England or of Ireland. If horses fell lame, it was from causes incidental to the climate, and for these the system of shoeing would supply no remedy. From other diseases, which from strong and often incontestable reasons may be traced to the use of shoes, they were wholly free. The necessary conclusion was that the system of shoeing could answer no good purpose, while it might be productive of much harm; and in this conclusion he was confirmed by the admissions and protests of the most able and competent veterinary surgeons in this country. These have uniformly raised their voices against the heavy weighting of the horse's foot maintained by the traditional practice. It has been found here that the hoofs of some horses are so weak that they can not be fully shod; and a writer in the "Field," styling himself "Impecuniosus," cited some ten years ago a remark by Mayhew that "some horses will go sound in tips that can not endure any further protection," adding the significant comment that the moral of this is that "it is the shoe, not the road, that hurts the horse"; for, if a weak and tender foot can go sound when all but unshod, "why should not the strong, sound one do the same?" The conclusion, as he insists, should rather be that a horse must have a strong, sound foot to stand, not our work, but our shoe. The same writer, speaking of the cruelties unwittingly perpetrated by grooms and blacksmiths on the horse's foot, says that, "though lameness usually attends their efforts, they ascribe it to every

cause but the right one, and, indeed, resign themselves complacently to the presence of many diseases confessedly caused by their treatment." "Free Lance" has seen, and others also have doubtless seen, light horses, of high breed and value, shod or burdened with a full set of shoes in which eight nails, nearly three sixteenths of an inch in thickness, were driven four in each quarter, and in a space of three inches for each four nails. He may well call attention to the immense amount of laceration and compression which the delicate hollow fibers of the crust must have suffered when thus wedged up within a fourth of their natural dimensions. Besides this, he adds, the hoof was, in one instance, carved out on the crust to receive three clips, one on the toe and one on each quarter. "A calk, three quarters of an inch high, was put on one heel of each hind-shoe, and, on the other heel, a screw cog of equal height. On each front-shoe a cog, also three quarters of an inch high, was put upon each heel. This wretched victim to fashion was then regarded with the utmost satisfaction by the farriers and his groom; and all this heathenism was perpetrated in the forge of a veterinary surgeon. But, perhaps, he was shoeing to order."

Among the reformers of these great abuses M. Charlier occupies a prominent place. His shoe in its first shape was not successful. Starting rightly on the assumption that Nature intended the horse to walk barefoot, and that the bottom of his foot was in every way fitted to stand all wear and tear, he excepted from these self-sufficing parts the outer rim, that is, the wall or crust. "He, therefore," "Free Lance" tells us, "made a shoe of very narrow iron, less than the width of the wall, which he let in, or imbedded, to the crust, without touching the sole even on the edge; so that, in fact, the horse stood no higher after he was shod than he stood when barefooted. He urged that such a narrow piece of iron would not interfere with the natural expansion and contraction of the foot; and in this he at once went wrong, for malleable iron has no spring in it. Then, in spite of his theory, as he expressed it, he carried his shoe right round the foot into the bars, beyond where the crust ceases to be independent of them. He then got a very narrow, weak shoe, about a foot in circumference (if circumference can be applied to that which is not a complete circle); and, as he ought to have foreseen, the shoe then twisted or broke on violent exertion." Still, as freeing the horse from a large amount of the weight usually attached to his foot, the change was an important benefit; and the lesson thus taught was not thrown away. The shoe was reduced by a man at Melton from the full to the three-quarter size, and in this form it weighs five ounces. Seeley's patent horseshoe, adopted by the North Metropolitan Tramways Company, weighs one pound and a quarter, this being a reduction of one half on the weight of the ordinary shoe; and we have to remember that each additional ounce on the horse's foot makes a most sensible difference in the amount of work performed by him during the day. Shoeing their

horses on the principle of the modified Charlier shoe, Messrs. Smither & Son, of Upper East Smithfield, have found the result marvelously to their advantage, in the measure of comfort and safety with which their animals do their work, whether in the London streets, on pavement, or on country roads. So far as their experience has gone, there are no horses which it does not suit, and it is of special service for young horses running on the London stones, and for horses with tender feet, or corns, and to prevent slipping. In other words, the absence of metal confers benefits which can not be bestowed by its presence. Facts in America teach the same lesson. At a meeting of the Massachusetts Board of Agriculture in 1878, Mr. Bowditch, a practical farmer, declared that "nine hundred and ninety-nine thousandths of all the trouble in horses' feet come from shoeing," that he was in the habit of driving very hard down hill, that he had galloped on ice on a horse whose feet had merely a small bit of iron four inches long curled round the toe, and that this piece of iron is all that is needed even in the case of an animal whose feet have been abused for a series of years. When nothing is left but this fragment of the traditional shoe, and when even this fragment has, as in Massachusetts and elsewhere, been retained for the fore-feet only, it is incredible that men should fail to ask what the use of this relic of the old system may be. Donkeys in Ireland are unshod, and they work on roads at least as rough, hard, slimy, and slippery as those of England. "Can one really believe," asks "Free Lance," "that the animal which is endowed with the greater speed and power should have worse feet than his inferior in both respects?" To such a question one answer only can be given; and the lesson may be learned by any one who will take the trouble to go to the wilds of Exmoor or Dartmoor. There, as in the Orkneys and on the Welsh hills and in many parts of the Continent of Europe, horses run unshod over rocks, through ravines, and up or down precipitous ridges. "Yet all this," Mr. Douglas remarks, "is done without difficulty, and to the evident advantage of their hoofs, for these animals never suffer from contracted feet, or from corns, sand-cracks, etc., until they become civilized and have been shod." Mr. Douglas, it is true, holds that civilization involves the need of a shoe of some sort for horses as for men; Mr. Mayhew advocates the use of the tip, and, as we have said, it is not in human nature to stop short at such a point as this. It is obvious that, if the complete abandonment of iron is followed by increased efficiency and power of endurance on the part of the horse, as well as by deliverance from a number of painful and highly injurious diseases, the owner is directly and largely benefited in more ways than one. His horses live in greater comfort and for a longer time; his veterinary surgeon's bill and the outlay for medicine are greatly lessened, and the costs of farriery disappear altogether.

Farriers will, of course, complain that their occupation is gone,

and that they are ruined men; but little heed was paid to like pleas when they were urged for the drivers and attendants of coaches and coach-horses when the first railways were constructed. Matters will adjust themselves in this case as they did in the other. But, that the change can not be effected in a day or a week, no one will venture to deny. The feet of horses are ordinarily treated, not wantonly but through ignorance, with a cruelty which is simply shocking. With vast numbers of animals which are not kept for purposes of drudgery, and in whose appearance their owners feel a pride, the hoof is a mere wreck, and the sight of the mangled and split hoof may well excite not merely pity but wonder that any can passively allow such evils to go on. A few, however, will always be found with resolution enough to shake off the fetters of traditionalism; and some of these have already expressed their opinion with sufficient emphasis. One of these, writing in November, 1878, says: "The argument against horseshoes seemed to me so strong, and the convenience of doing without them so great, that I resolved to try the experiment. Accordingly, when my pony's shoes were worn out, I had them removed, and gave him a month's rest at grass, with an occasional drive of a mile or two on the high-road while his hoofs were hardening. The result at first seemed doubtful. The hoof was a thin shell, and kept chipping away, until it had worn down below the holes of the nails by which the shoes had been fastened. After this the hoof grew thick and hard, *quite unlike what it had been before.* I now put the pony to full work, and he stands it well. He is more sure-footed, his tread is almost noiseless, and his hoofs know no danger from the rough hands of the farrier, and the change altogether has been a clear gain, without anything to set off against it. The pony was between four and five years old, and had been regularly shod up to the present year. He now goes better without shoes than he ever did with them."

A well-known Cumberland farmer, writing about the same time, speaks of a farm-horse in his possession, which, having been lamed by a nail driven into its foot, had been for many months in the hands of the farrier. Tired out with this annoyance, the owner had his shoes taken off and turned him out to pasture. While still rather lame, the horse was set to work on the land; and he is now, we are told, "doing all sorts of farm-work, and dragging his load as well as any shod horse, even over hard pavement." If judgment based on knowledge is to carry weight, the question would soon be settled. We have already seen the opinions expressed by the most able writers on the horse, and especially on the structure and treatment of his feet, as well as by the best veterinary surgeons. The verdict of the "Lancet" is almost more emphatic. "As a matter of physiological fitness," it says, "nothing more indefensible than the use of shoes can be imagined. Not only is the mode of attaching them by nails injurious to

the hoof, it is the probable, if not evident, cause of many affections of the foot and leg, which impair the usefulness and must affect the comfort of the animal." If we add that the hunter is benefited almost more than other horses by being allowed to use his feet as Nature made them, the admission is made in the interests of the horse and not as an expression of opinion on the controversy respecting the right or the wrong of fox-hunting. It is enough to say that for horses which have to move rapidly, and to come down with a sudden shock on sticky and slippery ground, the natural course of the process of expansion and contraction is of the first importance. For those who may care nothing for the gratification of hunting-men, it may be amusing or provoking to learn that, in times of hard frost, hunters have been enabled to chase the prey by the aid of gutta-percha soles fastened to the feet; but all who are anxious only for the welfare of the horse will see in this fact strong evidence of the uselessness of the iron shoe. The plain truth is, that differences in the quality of soil, be it hard or soft, stony or sandy, smooth and slippery, are of comparatively little importance to the horse whose feet are as Nature made them. In the words of "Free Lance," "the unshod horse can successfully deal with all roads"; and assuredly no one will dream of asserting that shod horses can do this, for on the setting in of frost, for instance, they can not be worked until certain ceremonies have been gone through at the blacksmith's forge. The unshod horse can tread firmly on the slime of wood pavement when shod horses are slipping and struggling in agony around them; he can gallop on ice, and trot for miles together on the hardest and roughest flint roads, with far more ease and comfort than horses whose feet are shod with iron, or even with gutta-percha. "Free Lance" rightly remarks that "if they could not there would be an end of the thing, for evidently the horse should be able to go anywhere and everywhere, and at a moment's notice." It seems hard to produce the conviction that the natural sole of the horse's foot is almost impenetrable, that it is so hard and strong as to protect the sensible sole from all harm, and that all feet exposed to hard objects are made harder by the contact, provided only that the sole is never pared. This adequacy of the horse's foot to all demands that may be made upon it is forcibly illustrated by Mr. Bracy Clark, who, like Mr. Douglas and Mr. Mayhew, contented himself with striving to produce a perfect shoe, although he acknowledged that, if we wish to appreciate the full beauty of its structure, "we must dismiss from our views the miserable, coerced, shod foot entirely, and consider the animal in a pure state of nature using his foot without any defense. Probably Mr. Clark thought that, though we may consider it in its natural state, few can ever so behold it, as all horses in civilized countries are in greater or less degree brought under artificial conditions. The plea is fallacious. The horse is clearly intended by nature to serve as a domesticated animal; and, so long as we do not interfere with the

proper functions of any part of its body (and the abomination of bearing-reins and other such practices interfere with them grievously and even fatally), we bring it under no conditions which it was not designedly calculated to encounter. Private owners and companies whose horses must be numbered by troops are naturally irritated by the accidents constantly occurring on smooth and slimy pavements or on rough and hard stone or flint roads, and in their disgust they now offer rewards for the invention of a shoe which shall render the horse indifferent to the materials over which he has to pass, and clamor for a uniform system of pavements in all towns. It seems strange indeed that no misgiving seems to cross their minds that they are taking thought of the wrong surface, and that they are scared by false terrors when they dread the contact of the unshod hoof with sand, granite, flint, wood, or asphalt.

It can not, indeed, be too often repeated or too strongly insisted on, that the foot of the horse in no way needs to rest on soft and yielding surfaces. The very opposite of this is the truth, and this truth was perceived as clearly by Xenophon as by the ablest physiologists of our own day. Speaking, as he says, not from theory, but from wide and varied experience, Xenophon insists that, in order to insure the healthiness of horses, stable-floors must not be smooth or damp, that they should be lined with stones of irregular shapes, of much the same size as the animal's hoof, and that the ground outside the stable, on which it is groomed, should be covered in parts with loose stones laid down in large quantities, but surrounded by an iron rim to prevent their being scattered. Standing on these, the horse, Xenophon adds, will be in much the same condition as if he were traveling on a stony road, and, as he must move his hoof when he is being rubbed down as much as when he is walking, the stones thus spread about will strengthen the frogs of his feet. It is not easy to repress a certain feeling of shame at the disingenuousness of modern writers who have tried to shirk the difficulty by saying that Xenophon had no knowledge of our hard roads. It is enough to reply that he speaks distinctly of roads covered with stones, and of the benefit which the horse derives from traversing them. There is not a word to justify a suspicion that he would have shrunk from the hardest roadway of modern times. Xenophon is thus in complete agreement with Lord Pembroke's remark, that the constant use of litter in a stable makes the feet tender and causes swelled legs. In his judgment the bare stone pavement will cool, harden, and improve a horse's feet merely by his standing on it. Acting on the same principle, Vegetius, as "Free Lance" remarks, holds that the floor of the stable should be made, not of soft wood, but of solid hard oak, which will make the foot of the horse as hard as a rock. It should surely be unnecessary to say that these writers make not the remotest reference or allusion to the shoeing of horses. It was impossible that they could notice a practice which was unknown

to the ancient world, and which is in truth simply a modern, as it is also a most uncalled-for, barbarism. No iron helped to produce the heavy sound of solid horn which Virgil ascribes to the fiery steed of Pollux. Of late years we have heard much of the unjustifiable waste of time spent on classical literature which has no practical bearing on the interests of modern life. It is unfortunate that Xenophon's treatise on the management of horses has not formed one of the subjects for the upper forms of our public schools; and it would be well if they were made to read with care a book written by one who wrote unfettered by the restraints of any traditional system, and who successfully brought the cavalry, as well as the infantry, of the Cyreian army of Greeks from the plains of Babylon to the shores of the Euxine. There they would see how thoroughly the rules laid down by the leader of the Ten Thousand for the selection and management of horses are in accordance with the highest scientific knowledge of the present day, and how happy an ignorance he displays of the long and dismal catalogue of diseases and miseries which a wrong-headed and ridiculous system has called into existence. No horses could be subjected to a more severe strain in every limb of their body than were those which Xenophon led from Cunaxa over the Armenian highlands to the walls of Trebizond; yet we hear nothing of any special difficulties arising from diseases of the foot or leg. It may probably be said with truth that the strain endured by those horses could be borne only by unshod animals. Paul Louis Courier, the French translator of Xenophon's treatise, was so struck by the apparent soundness of his method, that he put it to the test by riding unshod horses in the Calabrian campaign of 1807, and he did so with complete success. But that which with him was a voluntary experiment has been for others an involuntary necessity. This was the case with many of our cavalry-horses during the Indian Mutiny, and their riders have declared that they were never better mounted in their lives. In the retreat of the French from Moscow, the horses, "Free Lance" remarks, lost all their shoes before they reached the Vistula; yet they found their way to France over hard, rough, and frozen ground. In his invasion of America, Cortes could not carry about with him the anvils, forges, and iron needed for shoeing even the small number of horses which he had with him. But these horses did their work and survived it, and from them comes the fierce mustang of Mexico, which still goes unshod. There is great force in the remark of "Free Lance," that horses are not indigenous to America, this being their first introduction, and that the climate and locality, therefore, have not that influence over the hoof which they are commonly supposed to have. The small horses of the irregular cavalry at the Cape, which took part in the battle of Ulundi, had no shoes on their hind-feet, and few were shod even in front, but they held out longer and went miles farther than the shod animals; and no complaints were made of any of them falling lame, although, as "Free Lance" adds,

"sheets of wet, slippery rock, and rolling stones in river-beds, would be calculated to try the hoofs to the utmost."

But it is scarcely necessary to cite more instances of the vast benefits which those who have had the courage to leave the feet of their horses as Nature made them have received under the most varied conditions of work, of soil, and of climate. Humanity and self-interest here point in the same direction, and only folly of the most perverse kind will have the hardihood to fight for the maintenance of the existing system. The cruelties practiced (whether unwittingly or wantonly) on the horse's foot have been extended over a series of generations, but the only penalty which remains to be paid for the ill doing of years is the surrender of a few days or a few weeks of the labor of the animal which has been thus misused. On the other side, there is a certainty that we shall be entering on a course which will triple the length of time over which the efficiency of the horse will be extended, and which, therefore, will, within twenty years, have saved the nation a hundred and thirty-five million sterling. It will further insure the immediate saving of all the money now spent on farriery, and this saving, which must be at the least forty shillings a year on every horse, will amount to two million and a quarter; and there will be the further saving in straw as well as on medicines, nostrums, and remedies no longer needed for animals rescued from a system which was a fruitful source of discomfort, disease, and death. The angry controversies which the subject is now constantly calling forth and exasperating will at the same time disappear. There will no longer be an outcry for uniformity in the system of paving towns, for horses will go as well on one kind of pavement as on another. There will no longer be querulous demands on inventors for the devising of a perfect shoe, because it will be clearly seen that this perfect shoe has been furnished already by nature, and that it is only human ignorance and conceit which has marred the work of God. We may now look back with some feeling of envious regret on the wiser, because more natural, methods of the ancient world; and future generations will look back with feelings of simple wonderment at the infatuation which could submit without a struggle to a system which doomed the horse to unnecessary disease and agony and to a premature death, while it deprived his owner of wealth often sorely needed for his own welfare and that of all depending on him. Of the ultimate issue there can be no doubt; but it is still the duty of "Free Lance," as of all whose eyes are opened to the mischiefs of the existing system, to fight the battle to the end.—*Fraser's Magazine.*

DOMESTIC MOTORS.

By CHARLES M. LUNGREN.

III.—GAS AND ELECTRIC ENGINES.

THE gas-engine differs from both the steam and hot-air engine in the character of the expansion of the elastic fluid employed and in the mode of applying the heat. In the one the fire is used to convert water placed in a vessel exterior to the engine into steam, which, let into the cylinder, moves the piston by its expansive force; and in the other it is used to expand a volume of air contained in the cylinder or adjacent chamber.

In both, the heat is applied outside of the working cylinder, but the peculiarity of the gas-engine is that the heat is developed within the cylinder itself. A mixture of gas and air is by the operation of the engine drawn into the cylinder, and then exploded, the heat generated expanding the products of combustion, which, exerting a pressure against the piston, give it motion. Simple as is this mode of converting heat into work, the practical realization of it has been found to be exceedingly difficult, and it is only within a very few years that thoroughly serviceable machines have been constructed. The most economical result is obtained from expanding gases when the pressure they exert is a continuous and gradually diminishing one, such as that of steam in the steam-engine. With an explosive mixture, like that in the gas-engine, the expansion takes place with great rapidity, producing a sudden and unsustained pressure, from which it is difficult to get either an economical result or a steady operation of the mechanism. This rapidity of expansion can be decreased, and the pressure obtained approximated to that of the steam-engine, by altering the proportions of air and gas so as to produce a quick combustion instead of an explosion, and by introducing the gaseous mixture into the cylinder gradually, instead of all at once; and it is in this direction that the improvements have taken place which make the latest forms of gas-engine so superior to their predecessors.

Among the first engines to obtain a moderate degree of success were those of Hugon (1858) and Lenoir (1860). Neither of these was, however, very economical in the use of gas, and, previous to the engine of Otto and Langen in 1867, none were produced that were at all satisfactory in this respect. This was, however, objectionable, owing to the intolerable din it made when in operation.

While this engine was at best but a very qualified success, it has led the way to a machine which is very far from being so. In the Otto silent gas-engine, introduced a few years since, and now made

in this country and Europe, and in both rapidly going into use, we have a machine that is a very satisfactory solution of the problems involved in the construction of this class of motors. In the matter of fuel it is nearly, if not quite, as economical as a steam-engine of corresponding power, and is, therefore, in actual use much more so, both

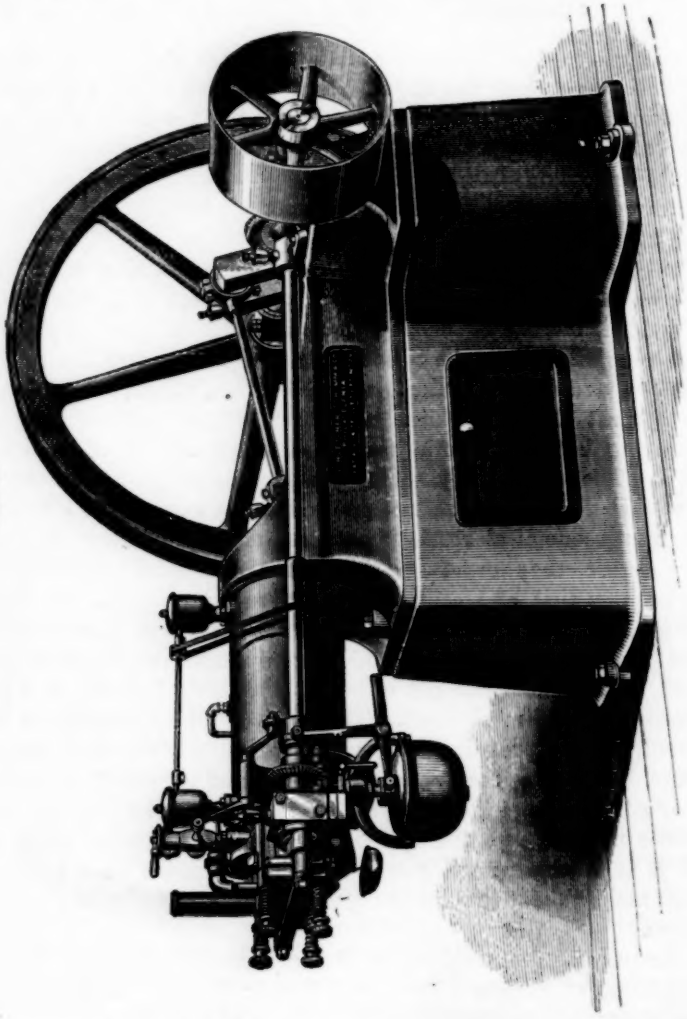
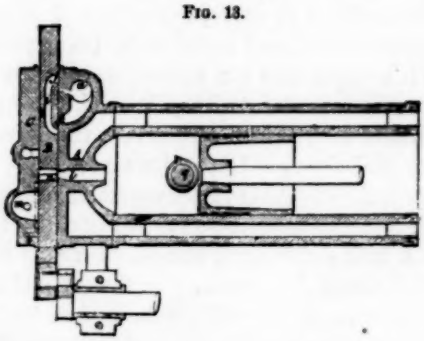


FIG. 12.

because no engineer is required to run it and the expense of keeping up steam, whether running or not, is avoided. The combustible charge introduced into the cylinder is composed of gas and air in such proportions that rapid combustion instead of an explosion takes place, and, to obtain sufficient pressure from its expansion, it is compressed to one third its original volume before being ignited.

In this country the engine is made for the trade in three sizes, from two to seven horse-power, but those of larger power are built when desired. The English makers furnish it from one up to forty horse, and as wide a range is given it on the Continent. The engine, as shown in the engraving (Fig. 12), is of the form constructed by the American makers. The cylinder is placed horizontal and overhangs the substantial bed-block of the machine. It is open to the atmosphere at the end toward the fly-wheel, and is closed at the other by a head-piece in which are the appliances for introducing and igniting the gaseous mixture, the construction of which is shown in the sectional cut Fig. 13. The head-plate A closes the cylinder entirely except at *l*, where there is a passage for the admission of the combustible charge. Between this plate and an outer one, C, is a slide-valve, B. The outer plate is pressed against the valve by the spiral springs shown in Fig. 12. The

FIG. 13.



pipe supplying the gas opens in its inner face at *c*, and at *m* there is a small jet constantly lit while the engine is in operation. The slide-valve B has two channels, *i* and *n*, the former placing the air and gas in communication with the cylinder, and the latter serving to ignite the mixture. The piston being at the beginning of its stroke, the valve B is in such a position that the air-inlet *a* and the gas-inlet *c* are in communication with the passage *l* through the port *i*. The piston then moves outward, drawing in a charge of air and gas which it compresses on its return, the valve B having moved so as to close the opening *l*. By this movement the channel *n* becomes filled with gas from the small supply-pipe *o*, which is ignited at the jet *m*. Just as the piston has completed the compression of the gaseous mixture, *n* arrives opposite *l* and ignites it, the valve continuing its motion so as to close the opening. The piston is driven outward by the expansion of the gases, and on its return they are expelled through the valve *q* in the side of the cylinder operated by the mechanism of the engine. The slide valve is reciprocated by a crank on the end of the lay-shaft, shown running lengthwise of the cylinder, which revolves but half as fast as the main shaft. The combustible mixture can therefore be drawn in only once

in two complete strokes, but whether a fresh supply is taken or not is determined by the governor, which acts to maintain a constant speed under varying loads. It is of the ordinary ball form, and is placed in the cup-shaped receptacle pendent from the cylinder. It actuates by its movement a lever controlling the gas-valve, so that this is opened and closed in accordance with changes in the speed. The regulation is delicate, and the speed nearly if not quite as uniform as in a steam-engine. The speed can be changed at will by increasing or diminishing the amounts of air and gas which may be drawn in each time. An automatic device is provided, which closes the gas-valve, should the engine by any accident stop in a position in which this would be left open. The oiling is committed almost entirely to the engine itself, the only work required in this connection being the filling of the oil-cups. They are placed upon the top of the cylinder, and by means of the small shaft and pulley driven from the lay-shaft deliver a given number of drops of oil to the slide-valve, cylinder, and piston at each revolution. The exhaust is rendered noiseless by being passed into a chamber, from which it escapes into the atmosphere under slight pressure. The cylinder is water-jacketed to keep it cool, the circulation of the water being maintained by the heat received, the warmer water rising to the supply-tank and the cool taking its place.

As before stated, the engine is very economical of gas. The amount used per hour per indicated horse-power is stated by the makers to be twenty-one and a half cubic feet, which, with gas at two dollars a thousand, is a trifle above four cents. In first cost the engine is somewhat more expensive than a good steam-engine, including boiler, of the same power, the price ranging from five hundred dollars for the two horse to eight hundred and fifty for that of seven horse-power. The former occupies a floor-space of about three feet by seven, and weighs fourteen hundred pounds, and the latter covers somewhat more space, and is of double the weight.

The heat generated by the combustion of the gas has been very fully utilized in this engine, but not to the greatest extent practicable. A certain portion of it is carried off by the water in the jacket, and is therefore wasted. If, instead of being allowed to escape without doing any useful work, it was employed to convert a small quantity of water injected into the cylinder into steam, overheating of the cylinder would be prevented, and at the same time this heat would be utilized. Besides the power gained, the use of steam is of value in giving a more sustained pressure on the piston and in lubricating the cylinder. Numerous attempts have been made to realize its advantages, both in hot-air and gas engines, but in most cases with no considerable gain in economy. The engine of Hugon, mentioned above, employed it, but apparently with little advantage.

Quite recently a gas-engine has been brought out in which the difficulties seem to have been mostly overcome, and which appears to ap-

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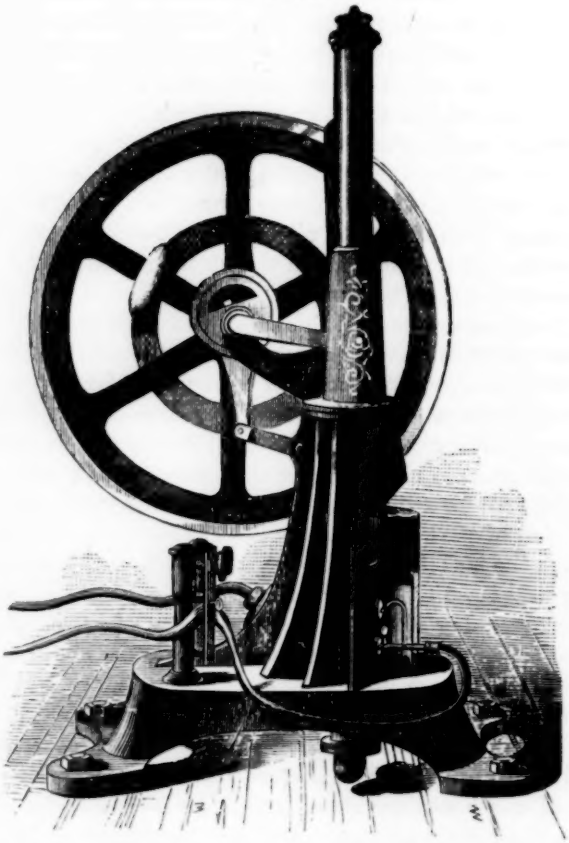
proach the limit of economy as closely as it is possible to do. It is the invention of M. Simon, and was first brought to extended public notice at the Paris Exposition of 1878, where it was exhibited in sizes of from one to four horse. A diluted mixture of air and gas is used, as in the Otto, but the compression is done not in the power but in a separate cylinder. It is admitted to the cylinder by a slide-valve of similar construction to that of the Otto, but the manner of using it differs materially from that employed in the latter machine. In the Otto the entire combustible charge is introduced into the cylinder before ignition takes place, and, though the proportion of air is such that the combustion is not an explosive one, still it is completed within a time that covers but a small fraction of the stroke. In the Simon, on the other hand, the combustible mixture is introduced in small quantities that are successively inflamed, producing a gradual expansion of the gases that, along with the steam also admitted, exert a pressure upon the piston more nearly like that in the steam-engine than is attained in any other machine. The ignition is accomplished by a jet always lit, placed just inside of several thicknesses of wire gauze, to prevent the flame retreating into the combustible mixture without the cylinder. The water that is afterward admitted to the cylinder is first used to jacket it, and thus becomes slightly warm. From the jacket it is passed into a steam generator, where a portion of it is vaporized by the heat of the exhaust-gases. This steam is then admitted into the cylinder along with the combustible charge, and further heated and expanded by the ignition of the latter. The water in the steam generator circulates through the jackets of both the compression and power cylinders, first taking heat from the compression cylinder, then from the power cylinder, and reaching the generator quite warm. The heat is therefore utilized to the utmost, and as a consequence the economical result is superior to any before attained. According to M. Simon, the consumption of gas is a little less than eighteen feet an hour per horse-power. The motor occupies a little larger floor-space than the Otto, though it is of less weight, and is somewhat higher in price.

Either of these engines could doubtless be made in sizes small enough to drive simply a sewing-machine or a scroll-saw, though probably not at prices that would allow of their extended use. Only one gas-engine appears to have been so far made of such small power—that invented by M. de Bisschof, and shown in Fig. 14. It is much simpler than the above engines, but is also a much less perfect machine, though sufficiently economical for the use for which it is designed. The ordinary machine is about one man-power, and is furnished at something over a hundred dollars; a larger one of four times the power costing a hundred and ninety. It is compact, ornamental in design, and runs smoothly. No oiling is required, and, once started, it may therefore be left to itself for a considerable time. One of them, indeed, is reported to have run for forty-seven days without

stopping, no attention whatever being given to it in that time. It is said to have gone quite largely into use in France, but it has not yet made its appearance in the American market.

In the engine as shown in the engraving, the cylinder is placed upright, and it and the base-plate are cast in one piece. A number of

FIG. 14.



ribs upon the former increase the radiating surface to such an extent that a water-jacket is unnecessary. The motor can therefore be readily moved from one place to another, an advantage of considerable value in the uses for which it is intended. The mixture of gas and air is admitted and discharged at the lower end of the cylinder through an opening, alternately placed in communication with the gas-supply and exhaust by a sliding valve. The firing of the gaseous charge is done by means of two gas-jets, shown on the right side of the engine. The lower one remains permanently lit, and serves to relight the upper one, which is extinguished at each ignition in the cylinder. This latter is placed directly opposite a small opening in the cylinder at about

one third of the piston-stroke from its base. The piston in its upward movement draws in a charge of the mixed gases during this lower third of its stroke, and they are then ignited by the jet, the remaining two thirds of the stroke being completed by the impulse due to their expansion. The atmospheric pressure and the fly-wheel carry the piston through its return-stroke, when the above motions are repeated. The supply of gas, both to the cylinder and the ignition-jets, is regulated by the pinch-cocks on the base of the machine, to the left. Before using, the machine is heated somewhat by a small burner placed below the cylinder. In the man-power machine the consumption of gas is eleven and a half feet an hour, which is a better result than is obtained with any other heat-engine of such low power. The motor seems to be in every way adapted to use in the household, and is probably as simple and perhaps as economical a heat-engine as can be made for the purpose.

The burning of a combustible mixture gradually, as is done in the Simon engine, was first successfully accomplished in the machine invented by Mr. George B. Brayton, and known in the market as the Ready Motor or Hydrocarbon engine. When first introduced, a dilute mixture of gas and air was employed, but in those now made the vapor of petroleum is substituted for the gas, with the advantage of a more satisfactory operation and a reduced cost of running. The working cylinder is surrounded by a water-jacket, and is placed upright in a substantial frame. It is open to the atmosphere below, the oil and air being supplied at the top. The oil is contained in a tank of from five to ten gallons' capacity, and is delivered to the engine by a small pump. Air is compressed by an air-pump in reservoirs, at the base of the machine, from which it is supplied to the cylinder. Only one of these reservoirs is used at a time, the other being kept charged so as to furnish an air-pressure with which to start the machine. The burner, by means of which the oil is introduced in the proper form into the cylinder and ignited, constitutes the main feature of the machine, and is at once simple and ingenious. It consists of a small chamber in the head of the cylinder, lined with a strip of felt against which the oil and a jet of air are delivered. The felt becomes saturated with oil, which the air-blast, passing through, carries in the form of a spray against the sheets of perforated metal and wire gauze which separate this chamber from the cylinder. Another and larger blast of air, in passing through the gauze, becomes carburetted by the petroleum vapor, and, entering the cylinder, is ignited by a jet placed immediately below the sheets of gauze. The jet remains constantly lit, and is prevented from retreating into the chamber above by the wire gauze. By simple mechanism the supply of air is cut off, when a part of the stroke has been made, and the combustion of the vapor ceases, the expanding products of combustion carrying the piston the remainder of the stroke. As the cut-off can be made at any point of the stroke, and

the expanding gases allowed to do the work of the remainder, the piston is subjected to a pressure entirely similar to and as readily controlled as that exerted by steam in the steam-engine. The piston is lubricated by its lower edge dipping into a shallow pan, F, at the bottom of the cylinder, containing oil, and the other parts in the ordinary manner. The motor is easily and quickly stopped and started, and when running requires but little attention. It is made in any size desired under ten horse, but those constructed for the trade are of three and five, the former being sold at four hundred and fifty dollars and the latter at six hundred. They are of about the same weight as the Otto, of corresponding power, and occupy a somewhat less space.

The engine is economical in the consumption of fuel, and with the present abundant supply of oil is the cheapest heat-engine of small power yet made. Five gallons of crude petroleum are used, it is stated, in the three, and seven and a half in the five-horse engine for ten hours' running. This is at the rate of one sixth of a gallon or one and a quarter pound an hour per horse-power in the smaller machine, and somewhat less in the larger. As the calorific effect of petroleum is almost double that of coal, the engine is nearly as efficient as a steam-engine of large size, and much more so than one of the same power, while, on account of the cheapness of petroleum, the expense for fuel is no greater. The oil used can be obtained in comparatively small quantities at from six to seven cents a gallon, and at the latter price the cost of a horse-power per hour would be a little less than one and a quarter cent, an expense considerably below the best results obtained in any of the engines using gas. This comparison is with the present cost of operating the latter motor, which is not one by which its possible economy is to be judged. The gas now used is the ordinary illuminating kind, and is high-priced. With a cheap fuel-gas, such as will assuredly come largely into use at no distant day, the cost would probably not be more than half that at present, and possibly less. This would bring it quite near that of the Brayton—near enough, at least, to make the advantage of the greater cleanliness and convenience of gas outweigh the gain in cheapness possessed by oil. An important objection to this engine is the one arising from the danger that accompanies the use of coal-oil. The motor itself is indeed quite safe, as much so as the gas-engine, and, if no more oil were stored than that in the tank from which the supply is drawn while working, the danger would be small. But when a considerable quantity is kept on hand in places where there is much valuable property, as in city buildings, the danger is sufficient to warrant increased insurance rates, and in some cases the prohibition of the machine. In situations where gas can not be procured, and where the use of oil would not be attended with the danger incident to crowded localities, it would probably be found one of the most satisfactory motors that can be had. Made in sufficiently small sizes of compact form, and with the oil receptacle and engine on one

base, it might easily become a serviceable motor for domestic use. As the quantity of oil used in such a machine would be small, it need not be in any way more dangerous than an ordinary lamp or oil-stove, and if properly finished would probably require but little more care. The oil used would of course have to be of a high grade, such as is used or should be used in lamps, and would cost considerably more than that suitable to the larger machines, but the expense of running would still be quite small.

Such are some of the best of the machines which the demand for comparatively small motors has, up to the present, called forth, and in the list those desiring such a power can scarcely fail to find something tolerably well suited to their wants. The various forms of heat-engines have been brought very close to the limit of possible simplicity, and show with some clearness what may be expected from further development along the same lines. They have been mainly designed to meet the requirements of industrial users, because the largest and most constant demand is from these ; but they are all capable of a reduction to the scale suitable in the household. For this purpose the gas-engine appears, on all accounts, to be the best adapted. Efficient and serviceable heat-engines are, of necessity, somewhat complicated, and require in their main parts an excellence and accuracy of workmanship that make it difficult to construct them cheaply. The gas-engine seems to be susceptible of greater simplicity of construction than any other of these, and can therefore be made at less cost. Present prices are undoubtedly high, but, with a sufficient demand and the competition that would result, they would decrease considerably, and it is not improbable that an efficient and economical machine of about one man-power could, under such conditions, be furnished at a price not exceeding fifty dollars.

But it is doubtful if such a machine would, after all, be the most satisfactory solution of the problem of a domestic motor. The final solution, there is reason to believe, is to be found, not in a heat-engine of any kind, but in a machine that will simply apply, in a convenient form and economical way, a power already furnished. Of such a nature is the water-wheel, which, for simplicity of construction, ease of handling, high efficiency, and small first cost, is unapproached by anything at present, and will probably never be surpassed by any future device. If water under sufficient pressure were everywhere obtainable, there would be no need of looking beyond this very simple and perfect contrivance. Water-power is, however, limited, and is generally least available where small motors are most wanted—in populous cities. Doubtless in many locations, where the windmill is employed to supply water to a house, a combination of wind and water power might readily be made which would prove quite satisfactory. A windmill of considerable power could be used to pump water into a properly elevated reservoir, or into a force-tank, from which it could be distributed to

small motors attached to the various pieces of apparatus to be driven. But generally, in cities where power could be distributed, people would prefer to have it furnished without thought or care on their part about its production.

For such a power, one that can at any time be increased to meet the utmost demands, we must, therefore, look to some other agency than water. Compressed air is, without question, an available one, and the motors in which it could be used are comparatively simple, but, as it could only be employed for this one purpose (unless, indeed, sanitary advantages were realized), the present or prospective demand would hardly warrant its adoption. The agent that appears to be the most suitable, and that gives promise of utility in other directions as well, is electricity. Distributed from a central source of supply, all the advantages of a safe and convenient power would be obtained, without any of the disadvantages attendant upon the use of other forms of energy. Of the feasibility of economically distributing the electric current there is a growing confidence among electricians, and the advantages of so transmitting power have been frequently urged of late, not only for moving light machinery, but for doing all the work now done in our factories by the steam-engine.

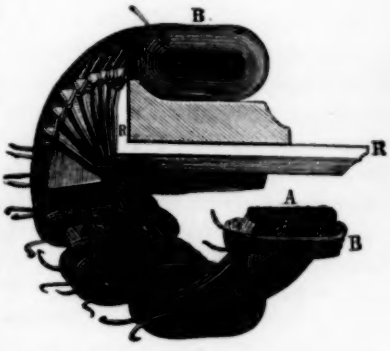
Distribution accomplished, the machines by which the current is utilized are very simple, and need not be expensive. As remarked by Dr. Paget Higgs, they are so much cast-iron and insulated copper wire, and their construction requires none of the skilled work necessary in the various forms of heat-engine. The construction is practically the same in the essential parts, whether they be used as current-generators or as motors. Briefly, such a machine consists of one or more electro-magnets placed so as to revolve before and very close to the poles of another electro- or permanent magnet, the former system of magnets being termed the armature, and the latter the field.

When permanent magnets are used for the field, the machines are known as magneto-electric, and, when these are replaced by electro-magnets, as dynamo-electric. The operation of both kinds depends, as is well known, upon the inductive action between the armature and the field magnets, a current being induced in each of the coils of the former as they approach, and an equal and opposite one being set up as they recede from the poles of the latter. In dynamo-machines the magnetization of the field is due to the currents generated by the machine itself. The soft-iron cores, after they have once been magnetized, always retain some residual magnetism which serves to induce a feeble current in the armature. A portion of this is sent through their coils, increasing their magnetization, which in turn augments the strength of the induced currents, and thus, by this successive action and reaction between the field and the armature, a very powerful magnetization of both is shortly produced. The currents are usually collected in such a manner that they both have the same direction in the circuit, by a sim-

ple device termed a commutator. This has various forms in different machines, but the principle involved is the same in all. The ends of the wire of the revolving coil are connected with the halves of a cylinder separated by an insulating substance. A metallic brush composed of bundles of wire, or thin strips, presses against each of these sections, and, so long as the cylinder remains stationary, the current taken off by the brushes will be an alternating one ; but, when the cylinder revolves with the coil, the brushes will change from one half to the other at the moment of the reversal of the current, and its direction in the circuit will, therefore, always be the same. In most machines the armature has many coils, and the commutator cylinder a corresponding number of insulated sections.

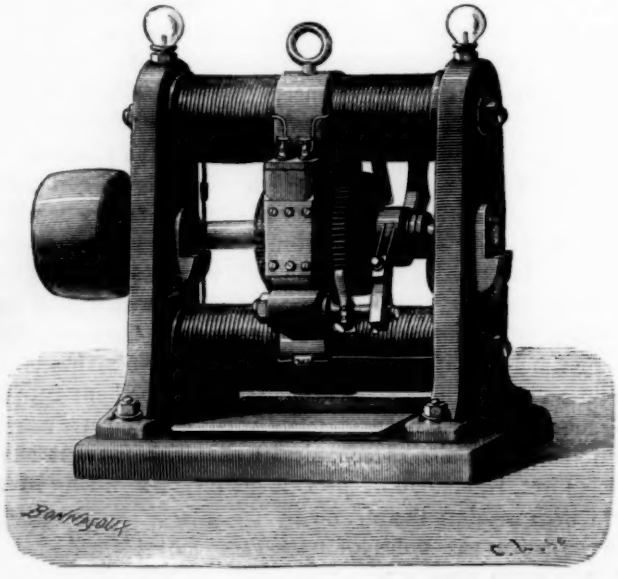
The interest in the electric light during the past few years has resulted in greatly improving such machines, and in the devising of many new forms of varied excellence. A description of one of these, that has attracted wide attention and proved one of the most efficient, will suffice to indicate the general construction and mode of action of such devices. When a magnet is inserted in a closed coil of insulated wire, a momentary current is induced in the coil, and, when it is withdrawn, one of opposite direction occurs. If, instead of withdrawing the magnet, it is passed through the coil, currents will be induced in each of its spirals as the magnet passes them, which will be in one direction during the passage of the first half of the magnet, and in a reverse one during that of the latter half. If two magnets be placed end to end with their like poles in contact, and be bent into the form of a ring, currents can be continuously produced by revolving the ring within an inclosing coil. Mechanical difficulties prevent such an arrangement ; but, if, instead of permanent magnets, a ring of soft iron be wound with insulated wire, and revolved between the poles of a magnet, the same results will be obtained and the difficulties avoided. The iron ring becomes a magnet by induction, and as it revolves its poles shift in the reverse direction, so as to always remain opposite those of the inducing magnet. The effect is the same as if the ring remained stationary and the coil revolved. This is the arrangement of the armature adopted in the Gramme machine, and the difference between it and others lies in this mode of inducing the current, instead of by insertion and withdrawal of a magnet from a coil. The manner in which the armature is actually constructed is shown in Fig. 15. The ring is composed of a bundle of soft-iron wires, about

FIG. 15.



which are wound a number of insulated coils. Radial pieces connected with the end of the wire of one coil and the beginning of the next conduct the currents to the commutator cylinder, when they are taken off by brushes. The armature is mounted upon a shaft and revolves between the poles of an electro-magnet, the arrangement being that shown in Fig. 16. When the machine is used on an electro-motor, the current enters the armature by the brushes and is alternately changed in direction by the commutator, so that there is attraction as the armature approaches and repulsion as it leaves the poles of the field magnet.

FIG. 16.



Besides machines constructed primarily to generate currents, but which may be used as electro-motors as well, there are various others designed especially for the latter purpose. The commonest form of these is a set of electro-magnets arranged radially around the armature, which is rotated under the influence of the changing polarity, or the magnetization and demagnetization of the field-magnets.

One of the best of the machines constructed for motor purposes, and one that has received high praise from competent electricians, is that of M. Marcel Deprez. It consists of a compound permanent horseshoe magnet with a Siemens armature between its poles. This latter is simply a soft-iron cylinder with two longitudinal grooves in which insulated copper wire is wound, the poles being the faces of the cylinder between the coils. It is placed with its axis parallel to the arms of the magnet instead of across them as is ordinarily done, and to this arrangement is due its greater power, as the whole strength of

the magnet is utilized. The current enters through the commutator, which reverses it at each half-revolution just as the poles of the armature are passing those of the field-magnet. The armature, therefore, rotates under these alternate attractions and repulsions. The rate of speed can be regulated with nicety by turning the brushes around the commutator cylinder to and from the neutral points. The speed is rendered uniform under a varying load by a very simple centrifugal governor, consisting of a small spring, one extremity of which is attached to an end of the armature coil, and the other rests against the commutator. When the speed increases beyond the normal rate, the free end of the spring is thrown out from contact with the commutator, and the current interrupted until this rate is regained. This governor has proved very sensitive in use, controlling the speed within variations of $\frac{1}{100}$ of its mean rate.

Excellent as this motor is, it has the defect common to all machines in which the armature is approaching or receding from the poles of the field-magnet during but a small part of each revolution. Currents are induced only during these periods, and hence much of the effective power of the field-magnet is lost. M. Trouvé has recently constructed a machine in which this defect is removed in a very simple manner. Instead of making the grooves in the Siemens armature parallel with its axis, they are cut in a spiral form, so that portions of the armature cores are approaching and receding from the poles of the field-magnet during the entire revolution. The impulse received by the armature is, therefore, a continuous one, and dead points are avoided.

The various electro-motors may of course be worked by currents furnished by ordinary batteries, and for running a sewing-machine a few hours a day, at a comparatively small cost. But, as a means of furnishing currents for power for any considerable time, such batteries are out of the question. As pointed out by Professor Ayrton, even if an electro-motor were a perfect machine—that is, if its efficiency were unity—it would be thirty-three times as expensive as a steam-engine, if operated by currents from such a source. The costliness of present batteries is, however, no necessary index of future possibilities. The most feasible way of obtaining power by electricity to-day seems to be through distribution of the current from a central point of supply; but it is not impossible that a battery may yet be produced which, furnishing electricity as cheaply as a machine, will remove the need of distribution, and at the same time greatly enlarge its field of usefulness.

THE VALUE OF ACCOMPLISHMENTS.

By WILLIAM A. EDDY.

SEVERAL years ago, Dr. Bellows delivered an able address at an annual meeting of the Mercantile Library Association of New York, in which he claimed that literary culture had increased the business capacity of the clerks who used the library. This will be readily admitted. But the question of improvement has moral significance aside from the advantage of a certain quickness or readiness of thought due to mental discipline. It is a law of the mind as well as of the physical structure that repetition of original or skillful action results in increased strength and efficiency, or in a stronger tendency to follow higher forms of thought and amusement. It is true that the proportion of moral action—that which is sane and proper to the mind—can not be represented arithmetically. Nevertheless, the higher kinds of thought may occupy in a general way an increasingly large proportion of the available time. But, as we can not set a definite limit, it is evident that at the present stage of development we are not justified in concluding that any system for displacing immorality can result in anything like perfection; all we can claim is that—taking a vast general average—higher tastes lessen the action of lower. The question of proportion is not so important, however, as the supremacy of a tendency, which in nature sometimes results in immense accumulations of power.

Men are at present in a state of imperfect self-control, and it is necessary that recreation should involve improvement, not only by keeping them out of mischief, but by establishing higher tastes. It is a gratifying fact that there is pleasure in any exercise of skill in art, in its subdivisions of sculpture, music, literature, or in the wonderful manifestations of natural phenomena inadequately grasped by the sciences. The enthusiasm with which art and science are usually followed is like that seen in children who carry out an original idea during play. The higher forms of action are thus spontaneous, and involve originality and force. This applies to small accomplishments as well as great—from the construction of ingenious devices for exhibition at a country fair to the work of Shakespeare, Beethoven, and Michael Angelo.

The great names of the world must not induce us to lose sight of the seemingly trifling manifestations of this force seen in original work followed according to liking, and known as accomplishments. It is to be regretted that this spontaneous action so rarely finds that full expression observed in men of genius in whom it overflows all bounds or obstacles. Some conditions can not be modified, so that

this originality must appear as recreation after the necessary mechanical work of the day is done. The obstacles tending to check independent action are innumerable, and sometimes absolutely insurmountable. A person may be deficient mentally owing to qualities inherited from a long line of stupid ancestors who manifested what Dickens calls "faint gleams of intelligence." In fact, objective events or objects that sweep into personal relation with us from out of vast extents of time and space are more modifiable by us than the almost unalterable conditions arising from hereditary qualities. The lack of power in a given direction may be practically beyond remedy, because very often there is not time in the life of one person for a form of force to reach anything more than primary stages of development. In special classes such limitation can recede greatly only in the course of generations in descendants who finally realize the ideal of Jean Paul Richter—the happy condition of liberty when sport is of service to the race.

Accomplishments are usually considered sources of amusement, although they must be paid for with a varying proportion of exertion not particularly pleasurable. In those forms of recreation in which we are mere passive spectators—often necessary as a relief from toil—there is an inevitable payment of either money, time, or labor. But, where the labor and sport are one, there is obviously a double reward.

It may be noticed, as a further extension of this truth, that the active or positive amusements are superior to the passive, for the reason that the passive do not stimulate the mind to conscious activity. There may be a high form of amusement as well as valuable mental discipline in the production of ingenious designs—such as articles for decoration, various products of carpentry-work, mechanical devices, chemical experiments, and so on. It is important to remember that some who have thus followed a liking for scientific or other knowledge have been stimulated to undertake tremendous feats of perseverance, whereby their names have lived for centuries.

The language learned and the skill acquired in painting or music seem trivial, but they establish an original habit of thought which incites others by force of example. Accomplishments indicate energy of character, for their pleasurable effect is largely due to a sense of power from having triumphed over obstacles.

In a world in which we are environed by dangers and mischances, every form of perseverance is honorable because it is either directly or indirectly helpful. The advances in enlightenment have come, not from those who are mechanical and passive, but from those of original force, who had ingenuity and other allied qualities by which practical effects are produced.

DARWIN ON THE MOVEMENTS OF PLANTS.

By ELIZA A. YOUMANS.

SINCE the time of Linnæus, men have wondered and speculated about what are known as the spontaneous movements of plants, and in recent years the causes of these movements have been carefully investigated by botanists. The subject in its various bearings now forms a large part of the science of vegetable physiology. The periodical and irritable motions of plants, and those due to light and gravity, have been closely studied in connection with the mechanical laws of growth, and many of these phenomena have been more or less satisfactorily explained.

But it has been reserved for Mr. Charles Darwin to go deeper into the facts and philosophy of the subject than any of his contemporaries. In 1875 he published a book upon "The Movements and Habits of Climbing Plants"; and he has since extended his inquiries so as to include the movements manifested by the entire vegetable series, except the lowest flowerless plants, and upon these he is now engaged. He has just published an account of these researches in a volume of six hundred pages, uniform with his other works.

One of the movements of plants long ago observed was described by the term *nutation*, which simply means nodding. The motion of a flower in following the apparent movement of the sun from the east in the morning to the west in the evening is an example of nutation, and this kind of motion has been found to be much more extensive in plants than was formerly supposed.

When we observe the growing stem of the hop, after the first two or three joints are formed, we see it bend to one side and travel slowly round toward all points of the compass, and continue these revolutions day and night. This spontaneous gyrating motion of stems and tendrils was first remarked by Palm and Mohl, and Professor Sachs gave it the name of *revolving nutation*.

Mr. Darwin has found that this kind of motion is ever present in the growing parts of plants, so that it must be regarded as a universal property of growing vegetation, and he suggests for it the better term *circumnutation*. He has proved that even the buried stems and rootlets of germinating seeds make this movement so far as the surrounding pressure will permit.

By the most ingenious and delicate contrivances, and his own constant coöperation, Mr. Darwin has made it possible for the circumnutating organs themselves to indicate approximately the direction and extent of their movements. His arrangements for enabling organs to record their motions varied somewhat; but we give his own account of the general process:

"Plants growing in pots were protected wholly from the light, or had light admitted from above, or on one side, as the case might require, and were covered above by a large horizontal sheet of glass, and with another vertical sheet on one side. A glass filament, not thicker than a horse-hair, and from a quarter to three quarters of an inch in length, was affixed to the part to be observed by means of shellac dissolved in alcohol, which was so thick as to set hard in two or three seconds; and it never injured the most delicate tissues. To the end of the glass filament an excessively minute bead of black sealing-wax was cemented, below or behind which a bit of card with a dot was fixed to a stick driven into the ground. The weight of the filament was so slight that even small leaves were not perceptibly pressed down. The bead and the dot on the card were viewed through the glass plate, and when one exactly covered the other a dot was made on the glass plate with a sharply pointed stick dipped in Indian ink. Other dots were made at short intervals, and they were afterward joined by straight lines. The figures are therefore angular. If the dots had been made every one or two minutes, the lines would have been more curved, as when radicles traced their own courses on smoked-glass plates. When the dot on the card was half an inch from the bead of sealing-wax, and the glass plate (supposing it to have been curved) stood seven inches in front, the tracing represented the movement of the bead magnified fifteen times."

Another, and in some respects better, method was used when it was required to magnify the movement. The dots on the glass plate were copied upon tracing-paper, and joined by ruled lines with arrows to show direction, the first dot being made larger to catch the eye. Night movements are shown by broken lines.

Chapter I is devoted to the circumnutating movements of germinating plants or seedlings. The first experiment relates to the movements of the young rootlet or radicle of a seedling cabbage. In this case fuller details of the process are given, along with the diagram, than in any other, for which reason we reproduce it here.

FIG. 1.—BRASSICA OLERACEA: circumnutation of radicle, traced on horizontal glass, from 9 A. M., January 31st, to 9 P. M., February 2d. Movement of bead at end of filament magnified about forty times.

"A seed, with the radicle projecting ·05 inch, was fastened with shellac to a little plate of zinc, so that the radicle stood up vertically; and a fine glass filament was then fixed near its base, close to the seed-coats. The seed was surrounded by bits of wet sponge, and the movement of the bead at the end of the filament was traced (Fig. 1) during sixty hours. In this time the radicle increased in length from ·05 to ·11 inch. Had the filament been attached at first close to

the apex of the radicle, and if it could have remained there all the time, the movement exhibited would have been much greater, for at the close of our observations the tip, instead of standing upward, had become bowed downward, through geotropism [gravitation], so as almost to touch the zinc plate. As far as we could roughly ascertain by measurements made with compasses on other seeds, the tip alone, for a length of only $\frac{2}{100}$ to $\frac{3}{100}$ of an inch, is acted on by geotropism. But the tracing shows that the basal part of the radicle continued to circumnutate irregularly during the whole time. The actual extreme amount of movement of the bead at the end of the filament was nearly ·05 inch, but to what extent the movement of the radicle was magnified by the filament, which was nearly three fourths of an inch in length, it was impossible to estimate. . . .

"Another seed was treated and observed in the same manner, but the radicle in this case protruded ·1 inch, and was not fastened so as to project quite vertically upward. The filament was fixed close to its base. The tracing (Fig. 2, reduced one half) shows the movement

FIG. 2.—BRASSICA OLERACEA: circumnutating and geotropic movement of radicle, traced on horizontal glass during forty-six hours.

from 9 A. M., January 31st, to 7 A. M., February 2d; but it continued to move during the whole of the day in the same general direction and in a similar zigzag manner." The chapter contains fifty-four diagrams, giving the movements of all the parts of the seedlings of all sorts of plants.

Mr. Darwin thinks that these movements of the radicle are useful at least in enabling it to take the line of least resistance, if they do not directly aid it in forming a passage for itself; and he adds: "If, however, a radicle in its downward growth breaks obliquely into any crevice, or a hole left by a decayed root, or one made by the larva of an insect, and more especially by worms, the circumnutating movement of the tip will materially aid its descent; and we have observed that roots commonly run down the old burrows of worms." He says, further, that the force due to longitudinal and transverse growth materially assists the radicle in penetrating the ground. He experimented upon these points, and we give two of these experiments which relate to the force exerted transversely by the radicles of beans. We may say that these radicles have a sharp apex protected by a root-cap, and their growing part is more rigid than the part just above.

A stick cut in the shape of Fig. 3 was purposely split at the short end, the split reaching beyond the hole. As the wood was highly

FIG. 3.—OUTLINE OF PIECE OF STICK (reduced to one half natural size), with a hole through which the radicle of a bean grew. Thickness of stick at narrow end, ·08 inch; at broad end, ·16. Depth of hole, ·1 inch.

elastic, the split closed as soon as it was made. The stick and bean were buried in damp sand, the bean being placed so that the radicle in growing would enter this hole. After six days they were dug up, and the radicle was found much enlarged above and beneath the hole. The fissure was open to a width of four millimetres, but as soon as the radicle was removed it closed to two m.m. The stick was then suspended horizontally by a fine wire passing through the hole, and a little saucer was suspended beneath it to receive the weights, and it required eight pounds eight ounces to open the fissure to the width of four m.m.

Again, "holes were bored near the narrow end of two wooden clips or pincers (Fig. 4), kept closed by brass spiral springs. Two radicles in damp sand were allowed to grow through these holes. The pincers rested on glass plates, to lessen the friction from the sand. The holes were a little larger and considerably deeper than in the trials with the sticks, so that a greater length of a rather thicker radicle exerted a transverse strain. After thirteen days they were taken up. The distance of two dots (see Fig. 4) on the longer ends of the pincers was now carefully measured; the radicles were then extracted from the holes, and the pincers of course closed. They were then suspended in the same way as the stick, and a weight of three pounds four ounces was necessary with one of the pincers to open them as much as the radicle had done by transverse growth." This radicle had escaped beyond the hole, and flattened a little, as soon as it had slightly opened the pincers, which had somewhat lessened the strain. As a result of all his observations, he concludes: The radicle "increases in length with a force equal to the pressure of at least a quarter of a pound, and much greater when prevented from bending"; and "it increases in thickness, pushing away the damp earth on all sides with a force of above eight pounds in one case and three pounds in another."

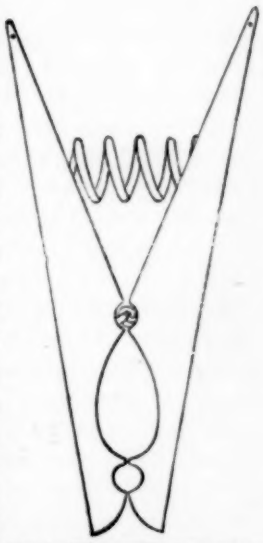


FIG. 4.—WOODEN PINCERS, KEPT CLOSED BY A BRASS SPIRAL SPRING, with a hole (·14 inch in diameter and ·6 inch in depth) bored through the narrow closed part, through which a radicle of a bean was allowed to grow. Temperature, 50°-60° Fahr.

To determine whether the growing parts of mature plants circumnutate, Mr. Darwin experimented with the representatives of about twenty genera, belonging to widely different families and various countries. Several woody plants were chosen, as being less likely to circumnutate. Plants in pots were kept at a proper temperature, either in darkness or feebly illuminated from above. Diagrams showing the circumnutation in about fifty instances of runners or stolens, flower-stems, leaves young and old, leaflets, fronds, etc., are given, and the volume contains about a hundred and fifty such diagrams, accompanied by explanations and comments bearing upon the argument of the book. The published instances are selected, for one reason and another, from an accumulation of similar material, the result of years of observation. The figures made by stems, which were always growing, are of course somewhat spiral, forming a succession of more or less irregular narrow ellipses, with their longer axes directed to different points of the compass at different times. They show that the course pursued is often interrupted by zigzags, loops, and small triangles. The rate of movement was different at different times and with different plants. Some made but one ellipse a day, and others four or five.

In studying leaves, he experimented with from thirty to forty widely distributed genera of dicotyledons, monocotyledons, and cryptogams. The seat of movement, he found, was generally in the petiole, but sometimes also in the blade. The extent of movement differed greatly. It is chiefly in a vertical plane; but, as the ascending and descending lines never agreed, there was always some lateral motion describing irregular ellipses. These observations were made upon healthy plants growing in pots, illuminated from above, many of them through ground glass, and they were also plants that do not sleep at night. The stem was always secured to a stick close to the base of the leaf under experiment. Besides his general conclusion that all growing parts circumnutate, many other important inferences are drawn by the author from these experiments and observations.

This movement, which in the case of climbing plants was believed to be due to increased growth of the side that for the time became convex, has more recently been proved to result from the circumstance that every part of a plant while it is growing, and in some cases after growth has ceased, has its cells rendered more turgescent and its cell-walls more extensile first on one side and then on another. Why this should be the case is not known, but Darwin suggests that the changes in the cells may require periods of rest, which accords with our knowledge of the rhythmical nature of motion.*

Under the microscope, this movement of circumnutation was seen in a few cases to be made up of sudden small jerks forward for ·002

* For an interesting and extended discussion of this subject, the reader is referred to the chapter on the mechanical laws of growth in Sachs's "Text-Book of Botany."

or ·001 of an inch, and then a slow retreat for part of the distance. No such movement could be detected with a two-inch object-glass, in the case of Drosera, and how far it is general is not known. Mr. Darwin says: "The whole hypocotyl (stem of a cotyledon) of a cabbage or the whole leaf of a Dionæa* could not jerk forward unless a very large number of cells on one side were simultaneously affected. Are we to suppose that these cells steadily become more and more turgescent on one side, until the part suddenly yields and bends, inducing what may be called a microscopically minute earthquake in the plant; or do the cells on one side suddenly become turgescent in an intermittent manner—each forward movement thus caused being opposed by the elasticity of the tissues?"

Mr. Darwin has shown the importance of this ever-present movement in successive chapters upon *modified* circumnutation. By this phrase he means that pressure and other irritants, light and gravitation, do not directly cause movement; they only modify the spontaneous changes in the turgescence of the cells, which are always in progress, and of which circumnutation is a universal consequence. He thinks that, in the case of seedlings, ordinary or unmodified circumnutation is clearly of service, directly or indirectly; but, in the later stages of growth, it is from various modifications of this constant motion that the plant derives benefit.

More than half the volume is given to the modifications of circumnutation by *epinasty* and *hyponasty*;† by nyctitropic or sleep-movements; and by the influence of light and of gravitation: but we can only glance at one of these, which is popularly styled the sleep of leaves, although there is probably no real analogy between the sleep of animals and that of plants.

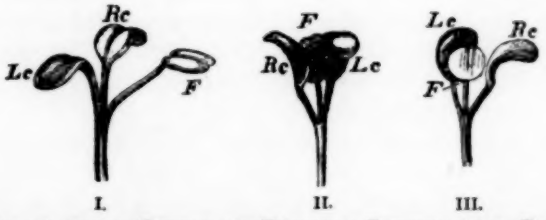


FIG. 5.—TRIFOLIUM STRICTUM: DIURNAL AND NOCTURNAL POSITIONS OF THE TWO COTYLEDONS AND OF THE FIRST LEAF: I. Seedling viewed obliquely from above, during the day: *Rc*, right cotyledon; *Lc*, left cotyledon; *F*, first true leaf. II. A rather younger seedling, viewed at night: *Rc*, right cotyledon raised, but its position not otherwise changed; *Lc*, left cotyledon raised and laterally twisted; *F*, first leaf raised and twisted so as to face the left twisted cotyledon. III. Same seedling viewed at night from the opposite side. The back of the first leaf, *F*, is here shown instead of the front, as in II.

Nyctitropic (*night-turning*) is the word used by Darwin to describe the sleep of leaves and occasionally of flowers, but, as flowers are affected chiefly by changes of temperature instead of light, their

* In these instances the jerking motions were very remarkable.

† The alternately more rapid growth of the upper and under surfaces of organs.

sleep does not so much concern the inquiry. The night-movements of leaves result from circumnutation modified by changes of light and darkness, and also by heredity; and, as Darwin has proved, they are chiefly of use to the plant in diminishing the loss of heat by radiation. Therefore, he says, no movement deserves to be called nyctitropic unless it has been acquired for this purpose. As some leaves and cotyledons bend upward only a little at night, the question arises, At what angle does the diminished radiation warrant the use of this term? He takes an arbitrary limit of 60°, above or below the horizon, as any less angular rise and fall would be of slight significance. Nyctitropic movements are easily affected by surrounding conditions of moisture and temperature, and in many genera it is indispensable that the leaves should be well illuminated during the day. From the very wide list of genera experimented upon, it follows that the habit of sleeping "is common to some few plants throughout the whole vascular series."

Darwin first considers the sleep of cotyledons, having observed the positions during the day and night of the representatives of one hundred and fifty-three genera. Some ten pages are given up to remarks upon this subject. We give his account of the behavior of the cotyledons of *Trifolium strictum* as it is illustrated by a picture of the diurnal and nocturnal positions they assume.

"On the first day after germination, the cotyledons stood at noon horizontally, and at night rose to only about 45° above the horizon. Four days afterward the seedlings were again observed at night, and now the blades stood vertically and were in contact, excepting the tips, which were much deflexed, so that they faced the zenith. At this age the petioles are curved upward, and at night, when the bases of the blades are in contact, the two petioles form a vertical ring around the plumule. The cotyledons continued to act in nearly

A. B.

FIG. 6.—OXALIS ACETOSELLA: A, leaf seen from vertically above; B, diagram of leaf asleep, also seen from vertically above.

the same manner for eight or ten days from the time of germination, but the petioles had become straight and were much lengthened. After twelve or fourteen days the first true leaf was formed; and during the next fortnight a remarkable movement was repeatedly observed. At I, Fig. 5, we have a sketch made in the middle of the day, of a seedling a fortnight old. The two cotyledons, of which

Rc is the right, and *Lc* the left one, stand directly opposite one another, and the first true leaf (*F*) projects at right angles to them. At night (see II and III) the right cotyledon (*Rc*) is greatly raised, but is not otherwise changed in position. The left cotyledon (*Lc*) is likewise raised, but it is also twisted so that its blade, instead of exactly facing the opposite one, now stands at nearly right angles to it. This nocturnal twisting movement is effected by the twisting of the whole length of the petiole. At the same time the true leaf (*F*) rises up vertically, or even inclines inward. It also twists a little, so that the upper surface of its blade fronts the upper surface of the twisted left cotyledon. The whole case is remarkable, as with the cotyledons of no other plant have we seen any nocturnal movement except vertically upward or downward."

The various ways in which the leaves of plants are protected from loss of heat by radiation at night are shown by diagrams and pictures from which we select some of the most striking. A good deal of space is given to an account of the circumnutation and nyctitropic movements of the *Oxalidæ*. In most of the species of oxalis the three leaflets sink vertically down at night. But, as their sub-petioles are short, the blades could not assume this position from want of space, unless they were in some manner rendered narrower, and this is effected by their becoming more or less folded (Fig. 6), so that their lower surfaces are brought near together (see B), as if the object were their protection rather than that of the upper surface. This would form a marked exception to the rule, that the object of sleep is protection of the upper surfaces from radiation, if it had not been found that, in species where the sub-petioles are longer, the leaflets sink without folding together. By thus crowding together at night, a much smaller surface is exposed than during the day.

A. B.

FIG. 7.—MEDICAGO MARINA: A, leaves during the day; B, leaves asleep at night.

"The drawing of *Medicago marina*, awake and asleep (Fig. 7), answers almost as well for *Cytisus fragrans*, which rose at night on one occasion 23° and on another 33°. The three leaflets also bend upward, and at the same time approach each other so that the base of the central leaflet overlaps the bases of the two lateral leaflets. They

bend up so much that they press against the stem; and, on looking down on one of these young plants from vertically above, the lower surfaces of the leaflets are visible: and thus their upper surfaces, in accordance with the general rule, are best protected from radiation. While the leaves on this young plant were thus behaving, those on an old bush in full flower did not sleep at night."

Again, "the species of Melilotus sleep in a remarkable manner. The three leaflets of each leaf twist through an angle of 90°, so that their blades stand vertically at night, with one lateral edge presented to the zenith" (Fig. 8). We have no room for the description of the

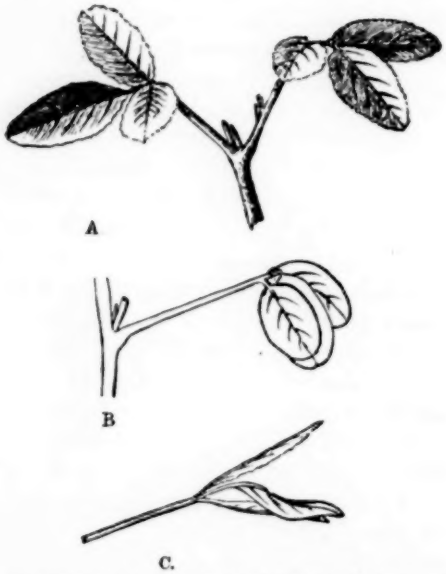


FIG. 8.—MELILOTUS OFFICINALIS: A, leaf during the daytime; B, another leaf asleep; C, a leaf asleep as viewed from vertically above, but in this case the terminal leaflet did not happen to be in such close contact with the lateral one as is usual.

complicated movements performed by these plants. Their petioles and sub-petioles are continually circumnutating during the whole twenty-four hours. Their cotyledons do not sleep.

The nyctitropic movements of eleven species of Trifolium were observed and were found to be closely similar. If we select a leaf of *Trifolium repens* having an upright petiole and with the three leaflets expanded horizontally, the two lateral leaflets will be seen in the evening to twist and approach each other until their upper surfaces come into contact. At the same time they bend downward in a plane at right angles to their former position, until their midribs form an angle of about 45° with the upper part of the petiole. The terminal leaflet merely rises up without any twisting, and bends over until it rests on and forms a roof over the edges of the now vertical and united lateral

leaflets, as seen in Fig. 9, with its lower surface fully exposed to the zenith.

The nyctitropic movements of ten species of the lotus tribe were observed and found to be alike. The main petiole rises a little at night, and the three leaflets rise till they become vertical, and at the

A. B.

FIG. 9.—TRIFOLIUM REPENS: A, leaf during the day; B, leaf asleep at night.

same time approach each other. In most of the species the leaflets rise so much as to press against the stem, and not rarely they become inclined a little inward, with their lower surfaces exposed obliquely to the zenith. The young leaves on the summits of the stems close up at night so much as often to resemble large buds. The stipule-like leaflets,

A. B.

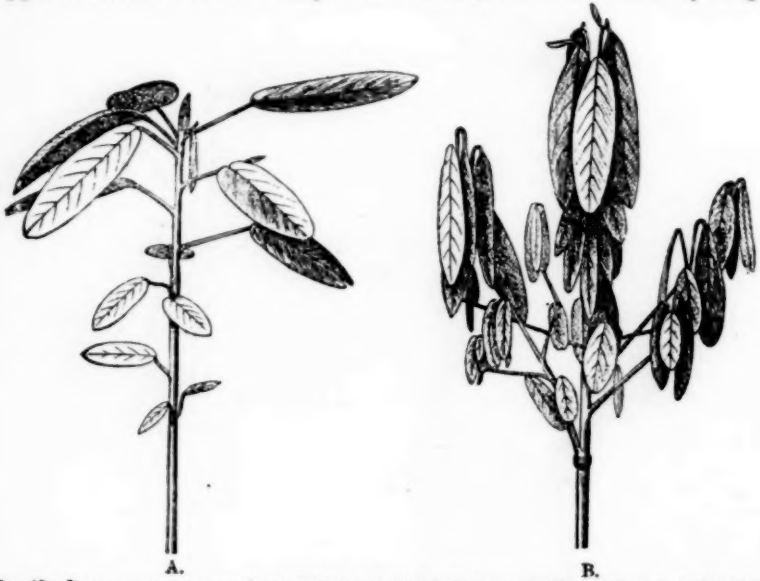
FIG. 10.—LOTUS CRETICUS: A, stem with leaves awake during the day; B, with leaves asleep at night; *ss*, stipule-like leaflets.

which are often of large size, rise up like the other leaflets, and press against the stem (see Fig. 10). The circumnutation of a terminal leaflet (with the stem secured) was traced during two days, but the move-

ment was so simple that it is not worth while to give the diagram. The leaflet fell slowly from the early morning till about 1 P. M. It then rose gradually at first, but rapidly late in the evening. It occasionally stood still for some twenty minutes during the day, and sometimes zigzagged a little.

FIG. 11.—CORONILLA ROSEA: Leaf asleep.

The leaves of *Coronilla rosea* bear nine or ten pairs of opposite leaflets, which during the day stand horizontally, with their midribs at right angles with the petiole. At night they rise up, so that the opposite leaflets come nearly into contact, and those on the younger



A. B.

FIG. 12.—DESMODIUM GYRANS: A, stem during the day; B, stem with leaves asleep. Copied from a photograph; figures reduced.

leaves into close contact. At the same time they bend back toward the base of the petiole until their midribs form with it angles of from 40° to 50° in a vertical plane (as in Fig. 11).

The appearance presented by a sleeping branch of *Desmodium gyrans* and by one in the daytime, copied from two photographs, is

shown at A and B (Fig. 12), where the leaves are seen at night crowded together, as if for mutual protection. Not less striking is the contrast between the night and day aspect of *Cassia corymbosa*, as seen in Fig. 13. Here the horizontally extended leaflets sink down vertically at night, and at the same time rotate so that the lower surface faces outward.

A. B.

FIG. 12.—CASSIA CORYMBOSA: A, plant during day; B, same plant at night. Both figures copied from photographs.

As a conclusion from all his experiments, observations, and reflections upon this subject, Mr. Darwin states:

"The great sweeps made by the stems of twining plants, and by the tendrils of other climbers, result from a mere increase in the amplitude of the ordinary movement of circumnutation. The position which young leaves ultimately assume is acquired by the circumnutating movement being increased in some one direction. The leaf-blades of various plants assume a vertical position through modified circumnutation, in order to protect their upper surfaces from being chilled

through radiation. The movements of various organs to the light, which are so general throughout the vegetable kingdom, and occasionally from the light, or transversely with respect to it, are all modified forms of circumnutation, as again are the equally prevalent movements of stems, etc., toward the zenith, and of roots toward the center of the earth. In accordance with these conclusions, a considerable difficulty in the way of evolution is in part removed, for it might be asked, How did all their diversified movements for the most different purposes first arise? As the case stands, we know that there is always movement in progress, and its amplitude or direction, or both, have only to be modified for the good of the plant, in relation with internal or external stimuli."

The discovery of the sensitiveness of the apex of the radicle was made by Darwin when he was looking for something else. Wishing to know how the radicles of seedlings passed over obstacles in the ground, he placed germinating beans in such a way that the tips of

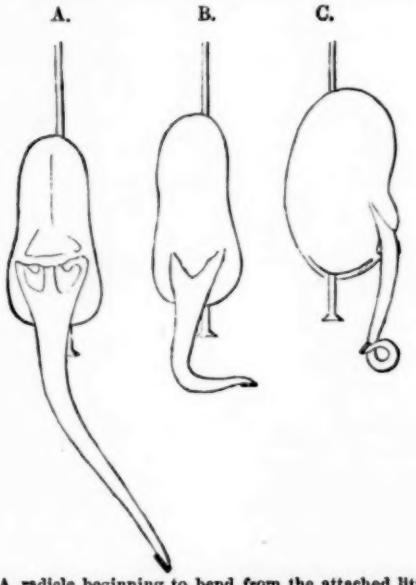


FIG. 14.—VICIA FABA: A, radicle beginning to bend from the attached little square of card; B, bent at a rectangle; C, bent into a circle or loop, with the tip beginning to bend downward through the action of geotropism.

the radicles came into contact with opposing surfaces at a high angle. When the root-cap touched such an obstacle it was at first a little flattened, but this flattening soon disappeared, and the apex took a direction at right angles to its former course. Straight lines had been painted along the growing terminal part of some of these radicles before they met the opposing objects, and the lines became sensibly curved in two hours after the apex had come into contact with them. The explanation of this curvature of the growing part could not be me-

chanical resistance, because it occurred when there was not pressure enough to produce it ; and, besides, Sachs has shown that the growing part is more rigid than the part just above it, which should have yielded first to resistance. Moreover, objects that yield with the greatest ease will deflect a radicle. After various attempts to explain the phenomenon, Darwin was led to suspect that the tip was sensitive to contact, and that it transmitted an effect to the upper part of the radicle, so exciting it to bend away. Such a thing had never been suspected, although Sachs discovered that the radicle is sensitive a little above the apex, and bends, like a tendril, *toward* the touching object.

Full details are given of the experiments by which this suspicion was verified. We can only say, briefly, that "germinating beans were pinned hilum downward inside the well-moistened cork lids of glass vessels which were half filled with water, and the light excluded. When the protruding radicles were the tenth of an inch or more long, bits of card about one twentieth of an inch square, or bits of sand-paper, were affixed to the sloping sides of their tips by means of thick gum-water, which by itself had no effect. To avoid confusion from the bending known as Sachs's curvature, the bits were never put in front." That the reader may have a clear idea of the kind of movement excited by the bits of card, we give, Fig. 14, sketches of three beans thus treated, which show the gradations in the degree of curvature. Out of fifty-five beans experimented upon, fifty-two were considerably bent away from the object attached, and the remaining three seemed to become sickly. As the radicle of the pea

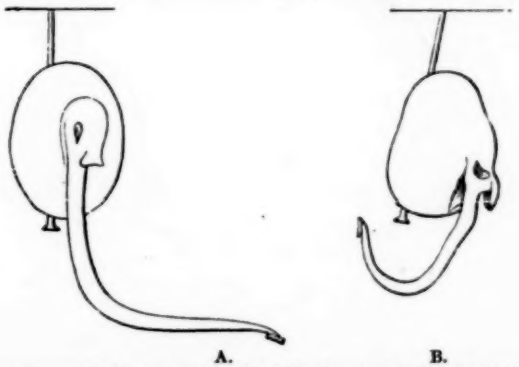
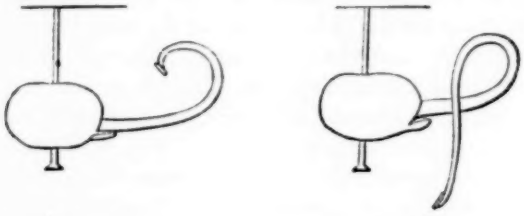


FIG. 15.—PISUM SATIVUM: Deflection produced within twenty-four hours in the growth of vertically dependent radicles, by little squares of card affixed with shellac to one side of the apex: A, bent at right angles ; B, hooked.

was found to be rather more sensitive at a point above the apex than that of the bean, he experimented with twenty-eight peas which had been soaked for twenty-four hours, and then left to germinate in damp sand. He tried them first with bits of card above the apex for Sachs's curvature, and thirteen of them bent toward the card, the greatest curvature being 62°. Bits of card were then fastened to one side of

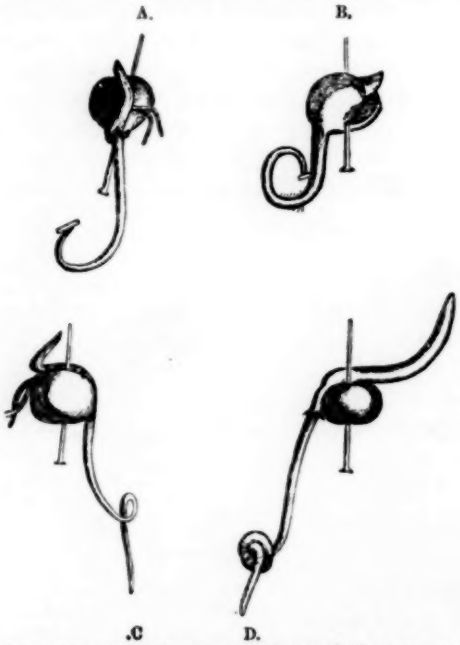
the tips of eleven radicles within the same jars, and five of them became plainly curved away from this side. In the former case the bend was abrupt, as shown in Fig. 15; in the latter a greater length of radicle



A. B.

FIG. 16.—PISUM SATIVUM.—A radicle extended horizontally in damp air with a little square of card affixed to the lower side of its tip, causing it to bend upward in opposition to geotropism. The deflection of the radicle after twenty-one hours is shown at A, and of the same radicle after forty-five hours at B, now forming a loop.

seemed to be affected and the curve was symmetrical, as seen in Fig. 16. He says, "It was a striking spectacle, showing the difference in the sensitiveness of the radicle in different parts, to behold in the same



A. B. C D.

FIG. 17.—ZEA MAYS: Radicles excited to bend away from the little squares of card attached to one side of their tips.

jar one set of radicles curved away from the squares on their tips, and another set curved toward the squares attached a little higher up."

His experiments upon the radicles of dicotyledons were numerous and varied in every way; but the seeds of Indian corn were the only

monocotyledonous ones which he observed. Omitting particulars, the cuts (Fig. 17) will show the effects produced in four instances.

In the case of A, the apex of the radicle is so much bent away from the square as to form a hook. At B, the irritation of the card, aided, perhaps, by geotropism, has formed a circle. At C, the tip in forming a loop has rubbed off the attached bit, and the circle has contracted, while at D, the apex, in making a second turn, passed through the first loop and so rubbed off the card, and, growing downward, tied itself into a knot.

Mr. Darwin believes that the tips of all radicles are similarly sensitive, and transmit an influence causing the upper part to bend. Moreover, the tip distinguishes between harder and softer objects, and between moisture and dryness. It is also sensitive to light and gravitation, and the course of the radicle in the ground is determined by the tip. The volume concludes with the following sentence: "It is hardly an exaggeration to say that the tip of the radicle thus endowed, and having the power of directing the movements of the adjoining parts, acts like the brain of one of the lower animals; the brain, being seated within the anterior end of the body, receiving impressions from the sense-organs and directing the several movements."

ATMOSPHERIC ELECTRICITY.

By Professor H. S. CARHART.

FROM the earliest periods the flash of lightning and the peal of thunder have excited curiosity, stimulated awe, and inspired fear in man; and according to his mythological, religious, or poetic habit of mind has he regarded the latter as the bolt of Jove, the voice of God, or the conscious utterance of the heavens. The explanation of these appearances in the sky is most curious and fantastic, even after the introduction of the modern inductive method. In a "Compendious System of Natural Philosophy," by J. Rowning, M. A., London, 1744, we find the following: "As vapors exhaled from the surface of water are carried up into the atmosphere, in like manner the *effluvia* of solid bodies are continually ascending thither. Now, we find by experiment that there are several inflammable bodies which, being mixed together in due proportion, will kindle into flame by fermentation alone, without the help of any fiery particles. When, therefore, there happens to be a mixture of the effluvia of such bodies floating in the air, they ferment, kindle, and, flashing like gunpowder, occasion those explosions and streams of fire which we call thunder and lightning."

Ever since Franklin identified lightning with the electricity of the frictional machine, an inquiry has been prosecuted into the origin of

atmospheric electricity. It has been ascribed to chemical action in vegetation, without any basis of proof; also with more reason to evaporation and to friction of solid and liquid particles against bodies on the surface of the earth. But friction fails to account for the fact that electrical displays, other than auroral ones, occur only during heavy precipitation of hail or rain, except in mountainous districts.

Deferring for the present what appears to be a probable account of the generation of atmospheric electricity, we may profitably review certain facts established by observation and experiment.

It is a matter of common observation that a small ascending jet of water is resolved into drops, which describe widely divergent trajectories. By reason of the different velocities and directions of motion of the individual drops, they come into frequent collision with one another and then rebound. The influence of electricity on the recoil of the drops after collision is most marked and interesting. About two years ago, Lord Rayleigh read a paper before the Royal Society on this subject, setting forth the results of his experiments.

When the ascending jet is strongly electrified, the drops do not collide, because of their mutual repulsion, arising from their charge of electricity of like sign. But with a very feeble charge the drops coalesce upon impact, and the breaking up of the stream is thereby much lessened. The rubbing of a glass rod across the sleeve in the vicinity of the jet suffices to prevent the rebound after collision; as also does the current from a single Grove element.

Further experiments, in which one of two contiguous jets was electrified, proved that the coalescence was due to a slightly different degree of electric tension in the impinging particles of water. In such case their attraction and coalescence are determined by static induction, the resulting force of which is always attractive; and with slight electrification the inductive effect always prevails over the repulsion due to like charges, when the charged bodies are brought near together. Hence strongly electrified particles do not actually collide, but are kept apart by electrical repulsion; while those feebly charged approach within the charmed circle where the attraction of static induction determines their collision and coalescence.

The bearing of these facts upon precipitation of aqueous vapor is obvious. Innumerable globules of water, feebly charged to different potentials, inevitably collide and coalesce into drops, which descend by gravity. A slight amount of electricity in the atmosphere is therefore favorable to aqueous precipitation, while a higher degree of electrical excitation is unfavorable to rapid condensation.

It is important in this connection to point out another conclusion bearing upon condensation of vapor—a conclusion reached by applying mathematics to the theory of electrified spheres or drops of water. An explanation of terms is essential to an understanding of the reasoning.

We have already employed the term "potential," a word of frequent occurrence in modern electrical works. An insulated, charged conductor exerts influence in every direction about it. The term "electrical potential" expresses the value of that influence at any specified point where there is electrical force. When any force acts, energy is expended in doing work; and the numerical value of the scientific expression "work" is the measure of the energy expended or the resistance overcome. "Work" means the product of the force into the distance over which it acts. The lifting of five pounds through a distance of ten feet requires the expenditure of fifty foot-pounds of work. Hence "electrical potential" may be defined in terms of work as follows: *The electrical potential at any point is the work required to carry a unit of electricity from that point to infinity.* It is of course understood that the "unit of electricity" is carried against the attraction due to an electrified body.

Potential is accordingly a mathematical and exact expression for all the work possible to be done against the attraction of a given amount of electricity resident at some specified place. In exactly the same way gravitational potential at any point may be defined as the work required to carry a unit mass of matter from that point to infinity against the attraction of gravitation.

Electrometers have been constructed by Sir William Thomson, with marvelous skill and inventive genius, designed to measure the potential at any point or of any body. It is susceptible of easy proof that the potential of a sphere, charged with electricity, Q, is everywhere equal to Q divided by its radius R. Further, the *capacity* of a body for electricity is the quantity required to charge it to emit potential; and, as potential varies with the charge, we readily find that the capacity of a sphere is numerically equal to its radius.

To apply this to condensation, suppose that drops of water of unit radius, unit capacity, and unit potential, coalesce to form drops of radius two: what will be the capacity and potential of such larger drops? Since the volume of spheres varies as the cube of their radii, eight of the small drops will be required to make one large one. The large drop will, therefore, contain eight times as much electricity as each of the small ones. As compared with the small drops, its capacity, being equal to its radius, will be only doubled, while its charge will be increased eightfold; and its potential will, therefore, be four times as great as that of the small drops, since potential of a sphere equals quantity of electricity divided by capacity of sphere. If its potential is quadrupled, its inductive influence on other bodies and its tendency to discharge are increased in the same ratio.

When, therefore, condensation occurs, aggregating minute globules of water into larger ones, the electric tension of the mass of descending vapor is immensely increased, without any corresponding increase in the total quantity of electricity present.

These two conclusions, applicable to condensation, may be applied to the frequently observed fact that a vivid flash of lightning is often quickly followed by a sudden and heavy down-pouring of rain. It is clearly impossible to tell which is antecedent to the other, the discharge or the sudden condensation; for, while the flash reaches the observer first, it is clear that light travels from the place of action with a vastly greater velocity than that of the falling rain, and the discharge may therefore have been subsequent to the sudden condensation. If the discharge occurs first, then the lowering of the electric potential permits approach of aqueous spherules and consequent coalescence after collision, in accordance with Lord Rayleigh's experiments. On the other hand, if the condensation is antecedent, it follows from the result reached above that it must be accompanied by a sudden rise of potential in the enlarged drops, leading to an electric discharge.

It will be observed that neither of these principles accounts for the original electrification of aqueous vapor in the air. It has been the custom to regard thunder-clouds as primarily charged by some unexplained process; and these, acting inductively, as producing a corresponding charge of opposite sign in the earth underneath. This view appears to have no conclusive evidence in its favor, but corresponds rather to appearances merely—a very unreliable guide.

In the theory here proposed, the earth is the charged body, acting inductively on the air, aqueous vapor, and clouds about it. Whenever moisture condenses to cloud, a better conductor is thereby formed, and increased inductive action takes place, causing an accumulation of electricity both in the cloud above and the earth beneath. If, then, the lower part of the cloud, under this inductive influence, condenses to rain and falls away from the upper part, a separation of the two electricities is effected, and an increase in potential results from the enlargement of the drops, as explained above. Consequently, a discharge may then take place either between the upper and lower cloudy strata, or between the lower portion and the earth, according as one path or the other offers the least resistance.

Further, when evaporation takes place from an electrified locality, the rising vapor must carry away a charge of electricity by convection, as air and dust carry away electricity from a charged conductor. The condensation of this vapor increases its potential, and, if sufficiently rapid, gives rise to electrical displays. It is a fact of recent establishment that "northern lights" occur in various high latitudes only with southerly winds, which come laden with moisture and probably with electricity.

The following considerations in favor of this view of the origin of atmospheric electricity may be briefly enumerated:

1. Continuous observations of the electrical state of the atmosphere at Kew Observatory and elsewhere for several years show that the air is always more or less electrified. The average potential of

fair weather being + 4, it was found rarely to fall as low as + 1; often during sudden showers it equals ± 20 or ± 30; during snow-storms with high wind it sometimes reaches + 100; and during thunder-showers, ± 100 and even — 200. A predominance of negative electricity is characteristic of thunderstorms. Hence some origin of atmospheric electricity, always operative, but in different degrees of intensity, must be sought. Clearly, any form of energy connected with mere cloud-formation will not answer the requirements.

2. The observations show also that the potential of the air is exceedingly fluctuating, no natural phenomenon being comparable with it in changeableness except wind-pressure. A change in the electrical state of the air indicates a corresponding change in the earth's surface. It is more reasonable to suppose that the earth, the great reservoir of electricity, should control the air and clouds electrically than that the clouds should control the earth.

3. The surface of the earth is perhaps never in electrical equilibrium; in other words, it is not an equipotential surface. Some time about 1865 Matteucci made prolonged experiments on earth-currents, and reached several interesting results. He found, for instance, that a tolerably steady current of electricity flowed through a line established along a meridian, uniformly from south to north; that fluctuating currents of low electromotive force flowed through an east and west line, sometimes in one direction, sometimes in the other; that when one terminal of a long line was in a valley and the other at a considerably higher elevation, a current flowed uniformly up the wire toward the more elevated end. A flash of lightning, in this case, was always accompanied by a sudden increase in the deflection of the galvanometer needle. ("Smithsonian Reports," 1867.)

4. Irregular and spontaneous earth-currents are the usual accompaniment of great terrestrial disturbances. James Graves showed in 1871 that spontaneous currents in the Atlantic cables frequently occur during earthquake-shocks. ("Journal Soc. Tel. Eng.," ii, pp. 80–120.) That spontaneous currents flow through land lines during auroral displays is a well-known fact. It is also asserted that any great meteorological change, as the motion of a heavy storm with considerable barometric fluctuation, is announced at a distance by irregular galvanic shocks through submarine cables.

5. Marked electrical disturbances in the atmosphere not infrequently accompany earthquakes and volcanic eruptions. A vivid flash of lightning was seen during an earthquake-shock in West Cumberland, England, on October 25, 1879. So frequently are these two phenomena conjoined that some writers have attributed South American earthquakes to electrical action. Lightning is often seen playing about the boundary between the condensing vapor from a volcano and the adjacent cool air.

6. Measurements of the potential of the air show that, as we pro-

ceed farther from the surface of the earth, the potential of points in the air differs more and more from that of the earth, the difference being approximately simply proportional to the distance. Also the electrical density is greater on projecting parts of the earth's surface than on those which are plane or concave. These facts are precisely what we should find to be the case in the vicinity of an irregular, charged conductor; and they are sufficiently explained if we regard the earth itself as charged with electricity varying in density. In fact, observations of the potential of so-called atmospheric electricity are simply "determinations of the quantity of electricity residing on the earth's surface at the place of observation." (Professor Everett, in Deschanel's "Natural Philosophy.")

In the Rocky Mountains electrical storms are of frequent occurrence. They consist of electrical displays without precipitation of rain, hail, or snow. Usually, though not always, the sky is overcast. In February, 1880, a remarkable electrical excitation was manifest at Boulder, Colorado. The miners were unable to kindle fire in the stove till eleven o'clock in the morning, every attempt to touch the metal about the stove resulting in a severe electrical shock. With every strong gust of wind the manifestations were more marked. Similar reliable evidence comes to the writer from other parts of Colorado. Long's Peak, an isolated mountain, 14,271 feet high, is noted for these peculiar electrical manifestations. The density of electricity on the peaks, projecting so far above the general level of the earth's surface, is greater than elsewhere; hence they possess a power to discharge like points on an electrified conductor. The air and aqueous vapor become surcharged with electricity; and only a slight condensation, sufficient merely to form clouds without rain, serves to produce discharges of lightning. With heavy gusts of wind the charged air is removed, and a fresh supply is provided into which the peak again pours its electricity.

In view of these facts, the theory is submitted as worthy of consideration that the earth itself is the seat of those disturbances that manifest themselves in atmospheric electricity. Fluctuating currents ebb and flow through the confining walls of this immense reservoir of cosmic energy. These follow naturally from the great changes in temperature to which the earth's crust is subjected; from those seismic disturbances occasioned by vast internal convulsions; from immeasurable local strain and compression, the result of upheaval and contraction. The earth, unlike the moon, contains still a vast store of unexpended energy; and in the ebb and flux of its mighty internal, contending forces, and the bending and swaying of its magnetic lines of force, in obedience to the magic wand of the sun, there is ample room for the generation of those comparatively feeble forms of energy that manifest themselves in the electrical disturbances of the air.

OPTICAL ILLUSIONS OF MOTION.

By SILVANUS P. THOMPSON, B.A., D.SC.

THERE are frequent occasions of conflict between the receptive faculties of the senses and the reflective faculties of the intellect, occasions on which the mind, prejudging of the sensation received, assigns it to a non-existent cause. Of all the senses none is more frequently the seat of such deceptive judgments than that of sight; and in the science of physiological optics a very considerable share of attention is claimed by optical illusions. For the purposes of convenience, we may draw a distinction between these illusions, which are the direct result of certain properties or imperfections of the eye as an optical instrument, and those which arise from obliquities of judgment in interpreting the sensations optically impressed upon the retina of the eye. In practice, however, it is almost impossible to draw a hard-and-fast line between the two classes of illusions, almost all partaking of both characters. Thus, for example, it has lately been shown that we habitually draw geometrical forms too large in the horizontal dimension as compared with their vertical dimension; we draw oblate ellipses where we intend to draw circles; the explanation of this being that with our *two* eyes we really *see* spheres as oblate ellipses. Here is, in fact, an illusion of pure association—yet based upon the facts of physical and physiological optics. So, again, certain inequalities in the curvature of the lenses of the eye, producing the optical defect of astigmatism, cause objects that are horizontal in position to form images at shorter (or longer as the case may be) distances from the eye than the images of vertical objects; the result being that, unless the defect is corrected by suitable lenses, vertical and horizontal objects (such as the bars of a window) do not appear to be at the same distance from the observer, though really equally remote. This would, at first sight, appear to be a purely physical illusion, and not psychological. Nevertheless, a little consideration will show that since our perception of distance is a psychological factor in the case, and that this perception is based in part upon the muscular sensations of adjustment of the lenses of the eye to exact focus, the illusion is one which has a psychological as well as a physical *raison d'être.* Again, take some illusions ordinarily supposed to be one purely of mental association: the common illusion of every day, that the sun or moon when a few degrees from the horizon looks larger than when high in the sky, appears at first sight to be due simply to the fact that when the orb is near the horizon the distant objects upon that horizon whose size we know, or can judge of, appear relatively small, and the sun's disk relatively large—in fact, that the illusion is one purely of association of ideas. Nevertheless, when we look a little closer into the matter, we

find that our simplest conceptions of angular or apparent magnitude are very closely bound up with, if not directly due to, the sensations of muscular fatigue in moving the eyeball or head so as to bring the successive parts of the object into the center of vision.

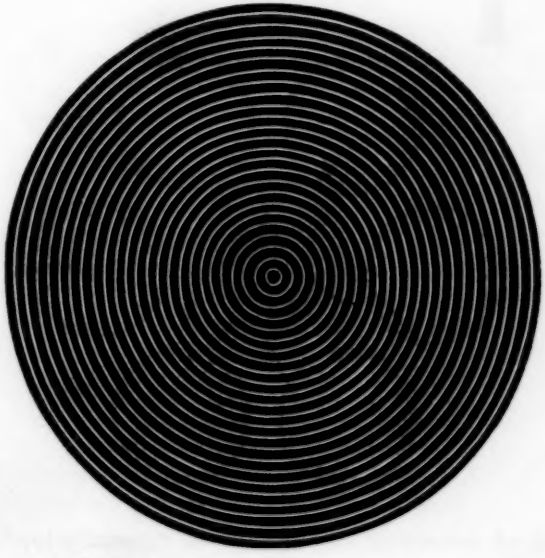
Hence, although optical illusions are of many diverse kinds—illusions of color, illusions of form, illusions of size, illusions of distance, illusions of solidity, and illusions of motion—they have all to be considered from the twofold standpoint, the purely optical and the psychological.

For some months the writer of this article was engaged upon a study of one set of optical illusions, namely, the illusions of *motion*, and a number of observations, collected at intervals over several years, have been added by him to the stock of knowledge previously gleaned by Brewster, Wheatstone, Faraday, Plateau, and others. Brewster made a number of observations, in the early days of railways, on the various illusions which can be found by watching objects from a moving train; Wheatstone investigated a curious case of apparent fluttering motion at the border of two brightly illuminated colored surfaces—due probably to the attempt of the unachromatic eye to obtain fruitlessly a distinct focus of the border-line between the unequally refrangible colors—known as the illusion of the "Fluttering Hearts"; Faraday investigated the illusions produced by intermittent views of moving objects, since developed in the phenakistiscope and zoetrope, and kindred toys, and due to persistence of visual impressions. Brewster, moreover, drew attention to the existence of another class of illusions—illusions of subjective complementary motion—the typical case of which occurs also in railway-traveling. After looking out of the window at the pebbles and other objects lying beside the line, as they pass before the eyes, let the eyes be closed suddenly, when there will at once be perceived an apparent motion in the opposite sense, undistinguishable forms and patches of light seeming to rush past the blank field. This was recorded by Sir David in 1848, and the phenomenon was referred by him to a subjective complementary motion going on simultaneously, and so causing a compensation of the impressions moving over the retina. A kindred phenomenon had been even earlier noted by R. Addams, who, in 1834, narrated how, after looking for some time at a waterfall and then at the water-worn rocks immediately contiguous, he saw the rocky surface as if in motion upward with an apparent velocity equal to that of the descending water. This he ascribed to an unconscious slipping of the inferior and superior recti muscles of the eyeballs, which he thought occurred while watching the falling water, and which he supposed to continue unconsciously after the gaze had been transferred to stationary objects. This explanation differs from the one offered by Brewster, namely, that there was a subjective *opposite* movement going on simultaneously, so causing a compensation of the impressions moving over the retina. Brew-

ster's hypothesis is, indeed, extremely vague, and is neither physical nor psychological in any exact sense. If understood physically, it means that there is actually motion in the retina itself, which is hardly conceivable, since the structure of the rods and cones almost precludes even any idea of vibration, or of propagation of waves of motion by vibration, much less any movements of them as a whole. And, if the explanation is intended as a psychological one, something further is needful before the principle of compensation here laid down could become intelligible.

The first experiments made by the writer of this article upon illusions of motion arose from a casual observation in 1876. He had been preparing, for the purpose of testing astigmatism, a set of concentric circles in black and white, such as those shown in Fig. 1. Happening

FIG. 1.



to shake the sheet on which the circles were drawn, he noticed an apparent motion of rotation to be set up. The illusion is easily produced by imparting to the pattern a slight motion of the same character as that adopted in *rinsing* out a pail, but with a very minute radius of motion. All the circles will appear to rotate with the same angular velocity as that imparted. Now, undoubtedly the persistence of visual impressions has a good deal to do with the production of this illusion, which, by the way, succeeds best when the circles make from two to four turns in a second, and when the radius of the imparted motion is equal to the thickness of one ring, so that each black or white band is displaced through a distance equal to its own width in all directions successively. Nevertheless, the persistence of visual impressions will

not explain all the facts of this curious illusion: for, in the first place, it is found that for increasing distances from the eye the concentric rings must be made wider if the illusion is to succeed; there being apparently one particular magnitude of their images on the retinæ which favors the production of the illusion. Again, if two such "strobic circles" (as I have called them) are printed side by side on one card, that set of circles seems to turn most effectively at which the eye is *not* looking. On stopping the "rinsing motion" suddenly, there appears to be, for an instant, a reverse motion. Finally, if a set of circles is "rotated" while another set lies motionless within the field of view, the second set will appear to rotate when the first are "rotated" in the manner described above. It is possible, also, to have a number of such apparent motions going on at once independently in one field of view. Fig. 2 shows a compound pattern, containing an

FIG. 2.

interior set of concentric circles and six internally-toothed wheels. When a very minute "rinsing" motion is imparted to this figure, the circles appear to whirl round while the toothed-wheels work slowly backward, moving through one tooth while the circles whirl round once. Here, again, persistence of vision is concerned—but not exclusively.

Dr. Emile Javal, the able director of the Ophthalmological Laboratory of the Sorbonne, has recently advanced an explanation of these illusions different from that adopted by the writer, and in substance identical with that advanced by R. Addams in the case of the waterfall illusion. He avers that the eye, in order to observe a movement, follows the moving body for an instant and then suddenly slips back; that this oscillation, frequently repeated, is associated with a sensation of motion in the particular direction in question; and that when the

eye is subsequently directed to a stationary object it continues the habit of thus oscillating, causing the observer to attribute to the object a velocity of opposite sign to that just observed. M. Javal alleges in support of this view the appearance presented in the ophthalmoscope of the retina of a person affected with *nystagmus*. This affection consists in continual rapid involuntary movements to and fro of the eye. The retina, under these circumstances, appears to be animated with a vibratory motion which M. Javal declares to be identical in character with the apparent movements of the circles. In another place, M. Javal has endeavored to prove that the interior and exterior recti muscles of the eyeball are more prone to this slipping than are the superior and inferior recti, and that these illusions of complementary motion succeed better for motions in an horizontal sense than for vertical and oblique motions. My own experience, and that of other observers, admits of no such conclusion being drawn.

An experiment of Brewster's, which the writer tried without knowing at the time that Brewster had employed it,* has an important bearing on the muscular-slipping theory. A disk marked out into black and white sectors, as in Fig. 3, was caused to rotate at about one revolution per second, so that the separate sensations of black and white were not confused. The eye was steadily directed for twenty or thirty seconds at the central point, and then the gaze was suddenly turned upon some fixed objects, or at a distant landscape. For two

Fig. 3.

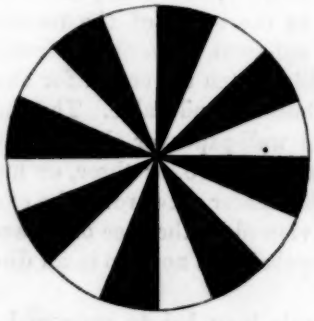


Fig. 4.

or three seconds a hazy rotation is noticed at the center of the field of vision. Now, if the muscular-slipping theory holds good, the complementary movement of rotation must be due to a slipping of the whole of the muscles of the eyeball, and would affect objects all over the field of vision with an equal angular velocity. This is not the case, the apparent complementary rotation being confined to the central field,

* The same experiment was also tried by my friend J. Aitken, Esq., of Darroch, Falkirk, who independently observed the phenomenon described by Addams, and who has also communicated to the Royal Society of Edinburgh a number of experiments on kindred illusions.

and with apparent angular velocities increasing toward the center of vision. Furthermore, I have arranged two such disks so that they could be simultaneously in the field of view while rotating in opposite directions. When the gaze was directed first at a point between them and then at fixed objects, there appeared to be two portions of the field of view rotating, and animated with rotations in opposed senses. Clearly, the eye can not slip round in opposite directions at the same time. In all these illusions, moreover, it is found that this illusory complementary motion only occurs over limited parts of the field of view—namely, those which correspond to the portions of the retina which previously received the moving images. Thus, if a waterfall be looked at—as in Addams's observation—the upward illusory after-motion is confined to a vertical streak across the field of vision. This fact alone is sufficient to negative the theory of muscular slip.

The final test to which I have appealed is, if possible, even more conclusive. It is probably a familiar observation that the end of the last carriage of a retreating railway-train appears to shrink down smaller and smaller as it subtends a decreasing angular magnitude in the field of view. After looking at this motion for a sufficient number of seconds to fatigue the eye, stationary objects appear to be expanding. To produce this illusion more effectually, I take a disk like that shown in Fig. 4 (the figure is quarter actual size), marked out in spirals of white and black. If this is slowly rotated—say at about one revolution in two seconds—the whole pattern appears either to be running into, or running out of, the center of the disk: there is a motion of convergence or divergence, according to the sense of the rotation. Let the disk be turned so as to cause an apparent convergence from all sides to the center, and let the eye steadily watch the center for about a minute, or until the fatigue becomes almost unendurable. Then look at any fixed object—the pattern of the wall-paper, or the dial of a clock—the object so regarded will for some two, or three, or more seconds, appear to be expanding from the center outward. The effect is still more startling if the object thus viewed be the face of a familiar friend. It is quite evident that the eyeball can not slip in all directions at once.

I have, therefore, somewhat reluctantly been led to propound an explanation for these illusions, embodying the theory of them in an empirical law based upon the physical fact of retinal fatigue, and on the psychological fact of association of contrasts. It is as follows: *The retina ceases to perceive as a motion a steady succession of images that pass over a particular region for a sufficient time to induce fatigue; and, on a portion of the retina so affected, the image of a body not in motion appears by contrast to be moving in a complementary direction.* This law is precisely similar to that of the complementary subjective colors seen after fatiguing the retina by the image of a colored body. Similar laws of physico-psychological after-effects are

abundant. A steady sound of one constant pitch ceases to be heard until we become aware of it by its cessation. A steady light of one color, such as the yellow light of gas-flames, ceases to be noticed as a yellow light until some other color-sensation break the illusion. The same is true of smells, of tastes, of the sensations of temperature, of the sensation of rotation after a waltz, and of many others. All these are probably only different instances of the operation of some much more general physico-psychological law. It is quite consonant with these kindred phenomena that, when any region of the retina is affected by an image of objects moving steadily across the corresponding portion of the field of view in any given direction, that portion of the retina gradually loses consciousness of the motion, and perceives it only as a steady sensation, or as one of approximate rest. When, however, an object really at rest is looked at, the associative faculty seizes upon the contrast in the sensations affecting that region, and interprets the new sensation by imputing a motion in the opposite sense to the objects occupying the corresponding portion of the field of vision. I have proposed to give to the empirical law expressing these matters the name of the *law of subjective complementary motion.*

It is impossible to quit the subject without pointing out two lines of thought suggested by that which has been advanced.

Firstly, it is conceivable that the explanation here propounded may at some future time be superseded by a better hypothesis of a more purely physical character. Suppose, for example, that it could be shown—what I have reason to suspect, but have been foiled in all attempts to prove in any experimental fashion—that the eye has the power of altering at will the actual size of the retinal images by a double muscular adjustment between the magnifying power of the lenses of the eye and the distance of their equivalent optical center from the surface of the retina, such a fact, once established, would entirely cut away the significance of my crucial test with the rotating spirals; and the apparent expansions and contractions of objects would be merely due to the continuous attempts of the eye to retain the retinal images of one constant size. If this were so (though I have failed in every kind of attempt to devise some satisfactory test), it might also explain one little matter that is still very mysterious and unexplainable, namely, that in these illusions of expansion and contraction the changes of apparent magnitude often appear to take place by discontinuous jumps rather than by steady motions.

Secondly, it is found that these different illusions affect different individuals with very different degrees of success, some persons being much more sensitive than others to the after-workings of the subjective motion; and, indeed, there are individuals in whose case it is almost impossible to produce the illusions. Doubtless some of these differences may be accounted for by defects of vision, astigmatism, achromatopsy, myopy, and the like. But there is also a time-element in

the case which varies very greatly with individuals, and even varies with the nervous states of the same individual. And this suggests the further thought that a careful comparison of individuals relatively to their illusion-capacity might elicit some interesting and perhaps valuable facts concerning the relation between the states of brain-organization and the sensations of the more highly specialized organs of sense. —*Brain.*

EVOLUTION OF THE CHEMICAL ELEMENTS.*

By LESTER F. WARD, A. M.

MUCH may be said in favor of the hypothesis of the progressive development of all the stable forms of matter by a true process of evolution from antecedent states. Indeed, in the higher forms of matter, in those which we know to be of composite constitution, this process is more or less thoroughly understood. Most of the objects which surround us, whether organic or inorganic, are known to consist of a great number of elementary parts of the same size and form which are aggregated in definite ways to form the general mass which each such object presents. These particles, which are alike for all parts of the same object or species of object, are unlike for different objects. Each object is an aggregate of elements of the same species, and these elements are the *units of aggregation.* All aggregates which have been thus far resolved into these units have confirmed this law. What is known, however, of the higher aggregates of matter is sufficient to establish another law, viz., that such aggregates are the result of the successive recompounding of units of aggregation of descending orders. The units of aggregation of aggregates of the higher orders are compounds of lower units. This is physically proved to be true of all aggregates of known composition.

In biology we have the individuals of various orders, both animal and vegetable, in which the lower forms are taken up bodily and made to enter as integral units into the higher forms. Not only are all animals and plants compounded of innumerable cells as ultimate biological units, but the earlier forms, which are aggregations of cells, are repeated as units in the higher forms. The tape-worm is an animal of the third order, the cell being taken as the first, but its segments are so feebly integrated that they possess all the essential characteristics of perfect animals. In the higher *Annulosa*, the integration is more complete, but the composite character is still evident. In the *Vertebrata*, the process of coördination has proceeded so far that only the

* Read before the Philosophical Society of Washington.

closest embryological study can reveal their composite nature. On the other hand, corals as well as many protists, such as the *Labyrinthuleæ*, coexist with so small a degree of integration that the parts are considered as distinct individuals, although clearly dependent on one another.

The vegetable kingdom illustrates still more clearly the manner in which the aggregates are compounded. We have plants, like *Caulerpa*, which, while the form would lead us to expect a considerable degree of organization, consist in reality of a simple aggregation of homogeneous cells. In higher plants, the leaf forms a new order of organization, and constitutes the morphological individual or unit. In trees, the process of compounding has gone so far that, considered as individuals, they may reach the hundredth degree.

If we contemplate the mineral kingdom, we are again shown the same truth. The various recognized minerals are not generally found to be composed directly of the simple chemical compounds into which they may be resolved, but consist of compounds of different orders into which the simpler compounds enter as units of composition. Thus feldspar contains silica, alumina, peroxide of iron, lime, soda, potash, magnesia, water, etc., as units of composition, none of which is supposed to exist in the mineral in any simpler state, and all of which are already more or less complex chemical compounds. Moreover, two or more of these minerals thus formed often again combine as new units to form others of still higher organization.

When we consider the facts which chemistry furnishes, we see the same law still operating in great simplicity. In many of the binary, ternary, and higher compounds, theory requires us to assume that the substances entering into them do so in their integral state, and are not first decomposed into their primary elements and then reorganized into the new compound. The hydrated oxide of potassium, for example, is not written KH_2O_2, but KO,H_2O, in which both the immediate constituents are regarded as maintaining their composite state and entering bodily into the new compound. The entire series of "compound radicles" requires the same supposition and illustrates the same general principle. Cyanogen (CN), ammonium (NH_4), methyl (CH_3), ethyl (C_2H_5), and the rest are now held to constitute integral units in the formation of the hydrides, alcohols, and acids.

So far, then, as induction can be depended upon, we find that it is a universal law of the aggregation of matter that each new aggregate may become a unit for the formation of aggregates of higher orders. Does this law cease with the so-called chemical elements, or are these themselves the products of molecular aggregation?

Without discussing the old and apparently insolvable problem of the divisibility of matter, it may be remarked that while the known facts of science are entirely satisfied with the hypothesis of an ultimate, finite unit of matter, of which all perceptible objects are but

aggregations, at the same time they do not conflict with such a modification of that hypothesis as assumes the actual magnitude of these units so far reduced as to be practically infinitesimal. They only declare—but this they do in the most emphatic manner—that this reduction must not be so far continued as to make the ultimate atom equal to zero, in the sense of absolute nullity.

On this view, which is by no means a new one, of the ultimate constitution of matter, the units of the so-called chemical elements, even of those having the smallest atomic weights, may themselves be of a relatively high order of aggregation or organization, below which many degrees may exist in which the molecules are too minute to form bodies which the senses can in any manner detect. The interstellar ether may be explained as constituting one of the highest of these degrees, yet not high enough to form matter such as to be visibly subject to the law of gravitation. The nebulæ present the evidence of the lowest form of such so-called "ponderable matter," and these may be supposed to be the result of a gradual development resulting from the successive recompounding of the molecular aggregates, until they finally acquire a certain influence over one another and tend to molar aggregation, forming the nebular masses. At the outset these aggregates may be supposed to be entirely homogeneous, consisting wholly of molecules of the same degree of aggregation, but they soon differentiate into several distinct kinds of matter. These are the gases which the spectroscope reveals in some of the nebulæ. They have molecules of low atomic weights and remain gaseous at all temperatures artificially producible. This process of evolution, which is the same which we have seen to go on in all the well-known forms of matter, would seem also to continue throughout the history of the nebulæ and the organization of resultant planetary systems, developing many additional forms of matter, likewise characterized by the increasing mass of their molecules.

What the properties of those molecular aggregates may be whose activities can not be revealed to sense, is of course unknown. Conjecture even as to the probable number of degrees of aggregation from the ultimate atom to the supposed atom of hydrogen would of course be idle. But that such forms exist far down upon this inaccessible plane, having definite shapes, sizes, and activities, we are strongly led to assume, both by the facts already stated and by others presently to be set forth.

Passing over these lower stages, therefore, whose study belongs to the future of human science, or to possible beings endowed with finer faculties, and which may be said to belong to the domain of transcendental chemistry, we finally arrive at a class of aggregates of great stability, but which, though still so minute that they can only be perceived when accumulated into masses, have nevertheless been studied in their free state by means of the various phenomena to

which they give rise, either in their natural condition, or, as is usually the case, under certain artificial conditions to which the ingenuity of man has learned to subject them. As these aggregates are the lowest which can be perceived, they have been denominated elements, and are by some supposed to constitute the ultimate units of matter. But, independently of certain direct evidence against this view, it is far more consistent with what is now known of matter, and with the laws of thought, to regard them as the first or lowest stages of aggregation whose activities are capable of appealing, either directly or indirectly, to our senses. It is really no more probable that the so-called elements are the lowest subdivisions of matter than that the remotest stars visible are actually at the confines of the universe.

That these elements are capable of manifesting themselves to sense is the sole reason of our recognizing their existence; and the history of their discovery, by which their number has been so greatly increased, shows that their modes of manifestation are often so subtile as to escape all but the most thorough methods of detection. Many of these elements now universally recognized remained for a long time wholly unsuspected, and these then belonged to the great class of unknown aggregates. This interesting chapter in the history of science should suffice to teach us that below the known of to-day there lies a wide belt of the knowable unknown, and that other and still lower orders of aggregates will doubtless yet be induced to reveal their existence.

A reason for regarding these elementary substances as ultimate units has been supposed to be found in their great stability, which causes them to behave as if such were the case.

While there is one possible exception to this in the case of oxygen and the peculiar phenomena of ozone and antozone, it is indeed true, so far as known, of all the remaining elements, that they have thus far resisted all attempts to decompose them. This, however, aside from the possibility of doing so still, is really no evidence of their absolutely elementary character, but only indicates what the whole theory of evolution would admit, if not require, that all aggregates which could possess the properties requisite for the composition of such masses as are capable of affecting the senses, or of so affecting other masses as to make themselves known to the human intellect, must possess a degree of inherent stability sufficient to resist all human efforts to disintegrate them. While, therefore, it is very probable that, just as the alkalies and alkaline earths, which, at the beginning of the present century, were regarded as elementary, have yielded to the galvanic battery and proved to be composite, so a few more of those now classed as elements will at no distant day be similarly decomposed by the higher appliances yet to be devised; it is nevertheless entirely consonant with the view of the constitution of matter here maintained, that there shall remain upon the plane of human investigation a

greater or less number of wholly undecomposable aggregates, serving as the primary basis of all tangible substances.

It must be expected, however, that these elements will possess all degrees of capacity for manifesting their presence, and that while some will stand out boldly, cohere in vast masses, like iron, for example, and in various ways render themselves obvious and obtrusive, others will be ever hugging the confines of the imperceptible, and, like ozone, will perpetually evade the full scrutiny of science. To this latter class also belongs the substance which emits the green ray of the solar spectrum, which has already led eminent chemists to conjecture that it may be of simpler constitution than any recognized element, if not the primary form of matter.

Setting out with the elements, regarded as aggregates of a comparatively high order and stable organization, but differing from one another in form, size, and molecular activities, as widely as the masses they form differ in properties, the problem of the formation of the higher orders of aggregates becomes comparatively simple. We find ourselves already in the domain of experimental science where the more or less completely demonstrated laws of chemistry and molecular physics lead us up to the formation of the various inorganic and organic forms of matter. The constitution of the various substances found upon the earth is readily determined by decomposing them and weighing their constituents. The precise conditions, however, which have resulted in their formation as we find them and brought about the existing state of things in the universe, are not so easily determined, and for this purpose a further extension of the general law of material aggregation is required.

The study of the earth's crust clearly indicates that very different conditions have existed upon it in the remote past from those which we now find. The facts as a whole prove beyond a doubt that our globe has once been in a state both of greater or less liquidity and also of great heat, and that, as its surface has cooled down, the solid parts, to which alone we have access, have been formed, though to what depth these extend we are still ignorant. But, notwithstanding certain doubts which have from time to time been cast upon it, the theory which was very early advanced as most in harmony with the probable history of the planet, and according to which the cooling process has not yet reached the great interior, which is therefore still in a heated and molten condition, still furnishes, perhaps, the most rational explanation yet made of the phenomena which the earth presents, and also best satisfies the *a priori* requirements.

It is now generally believed that the present condition of our earth, and also that of the entire solar system, has been the result of a cosmical process of development by which its matter, unchanged in quantity, has been slowly condensed from a diffused nebulous state, occupying enormously increased space—a condition analogous to, if not

identical with, that which is now presented by a large number of irresolvable nebulæ whose spectra show them to be composed of gaseous matter in an incandescent state. This gaseous or nebulous condition, though exceedingly rare relatively to the solid forms of matter familiar to us, is nevertheless a state of a high degree of aggregation as compared with the forms of matter by which it is surrounded and with its wholly unaggregated state. Before the operations which may be designated as molar can commence, a degree of aggregation must be reached far exceeding that which exists in those molecules which are the vehicles of luminiferous radiations. The particles constituting the ethereal matter of interstellar space must be supposed to be so minute and relatively far separated as not to exert any appreciable influence upon one another tending to produce molar motion or organization ; a condition which is explained on the same grounds as the fact that one system in space exerts no appreciable influence upon another system.

If the so-called chemical elements are simply so many stable molecular aggregates, whose differences are due to different modes and degrees of aggregation, then the gases of our earth are simply the most diffused state in which masses of these aggregates can be obtained. A gas is a diffused mass of homogeneous molecules, and this definition is as true of the compound gases, steam, carbonic acid, or vapor of alcohol, as it is of the simple ones, such as hydrogen, nitrogen, or vapor of mercury. It might, then, be naturally supposed that the nebulæ would contain a number of such gases, and as it is scarcely to be presumed that all the modes of forming stable aggregates are represented on our planet, so, in addition to some of those found here, it is reasonable to expect that nebulæ will contain some not known to us. In so far as the spectroscope—to which, indeed, we owe all our positive evidence of the existence of true nebulæ—is able to inform us, this view is confirmed. Two of our commonest gases, hydrogen and nitrogen, have been identified in nebulæ, while a third has been discovered which has not yet been identified with any known element.

Every modification of the nebular hypothesis yet put forth has been compelled to assume that the original nebulous mass must be in an incandescent state. Certain it is that all visible nebulæ are self-luminous. But this is a condition of their visibility. It can not be known how many may exist which have not yet reached this state, and are, therefore, invisible. It does not seem necessary to suppose that the contraction of a nebulous mass is either due to, or requires, a high temperature. No reason exists why cold particles may not become collected into a diffused mass. The inherent motions of these particles are not increased or diminished. But, these motions remaining the same, their circuits of motion are reduced, the frequency of contact is increased, and heat and light are evolved from the friction. The tendency of all matter under the law of gravitation, considered

as an unexplained fact, is toward concentration. The evolution of heat is rather the check put upon this tendency, and, in so far as it exerts any influence, it exerts it in a direction the reverse of gravitation. There is a perpetual and rhythmic antagonism between the forces of integration and disintegration. When for any reason the former acquires an impetus which carries it to great lengths, it is resisted with increasing violence by the antithetical force evolving great heat, and eventually restoring the normal equilibrium. It seems altogether probable, therefore, that in the process of contraction of a nebulous mass, and its resolution into a system of worlds, the amount of heat radiated is in the end equal to the amount produced by condensation, which disposes entirely of the supposition that there must exist an incandescent nebula at the outset. The so-called "cooling off" is only apparent, and, while at times the amount of heat may be diminished, at other times it will be correspondingly increased. If the radiation of heat from the surface of a body into space tends to cool it off, so does the constant diminution of its volume without loss of mass tend to heat it, and throughout its career these two influences must antagonize each other. It is only after the limit to possible contraction, due to the nature of matter itself, begins to be reached that the amount of radiation of heat comes greatly to exceed the amount of its generation, and that the body actually begins to cool off.

During the greater part of the history of an evolving system, the central mass must possess an enormously high temperature. This is required by chemistry as well as by physics. Throughout nearly the whole of this period, all the matter of the system must exist in the form of gas. But there exist in our globe many substances whose existence in the gaseous state presupposes great heat. The degree of heat required to volatilize the metals is immense, and there are certain other substances, such as silicon, for which still greater temperatures are demanded. It would, however, be a violent assumption to suppose that the parent nebulæ, out of which the solar system was formed, contained from the outset in this diffused state all the substances which are found on the earth. It is much more reasonable, and our hypothesis permits us, to assume that these substances, requiring so great heat to liquefy and volatilize them, have been *created*, i. e., *developed*, during the progress of the formation of the system out of materials already existing in other forms and states of aggregation. On the supposition that during the earlier part, and perhaps during all but the very latest period, of this process the temperature of the nascent system was increasing, it is reasonable to assume that the intense heat would cause the breaking up of some of the molecular aggregates which were capable of maintaining the gaseous form at low temperatures, and would at the same time cause the formation of new aggregates only capable of maintaining that form under the high temperatures to which they were subjected at the time of their for-

mation, many of which, nevertheless, would prove sufficiently stable to preserve the new form of aggregation after the temperature should go down, and, instead of reverting to their former condition on the cooling of the system, would assume successively the liquid and the solid states, and become constituent parts of and distinct substances in the cooled-off planets.

This theory of the origin of all those elementary terrestrial substances which require great heat to convert them into gas is supported by some facts. In the first place, none of the gases of these substances have been discovered in any of the nebulæ. The only two terrestrial substances, thus far determined with any certainty, are hydrogen and nitrogen. The latter of these exists in a free state in the earth's atmosphere, forming about four fifths of its volume and three fourths of its weight. The former does not exist in a free state in the atmosphere, in consequence of its strong affinity for oxygen, which is present there in excess, and whose union with it forms the waters of the globe. Both of these substances are gases at all temperatures producible by artificial means, and have only very recently been made to assume the liquid and solid states by the use of extraordinary devices. The other definite line which the spectrum of certain nebulæ presents is near to that of barium, but is conceded not to be the barium-line. It is, therefore, an unknown substance, and nothing can be said of its properties. Its proximity to the barium-line in the spectrum can not certainly be taken to indicate any special resemblance to that metal ; and it is probably a gas at low temperatures, like hydrogen and nitrogen.

In the second place, as to these two last-named substances, one of them, hydrogen, is present in nearly or quite all the self-luminous bodies whose spectra have been observed, where it seems to occupy a position far out in the upper atmosphere. As to nitrogen, its presence in such bodies is doubtful, so far as the spectroscope is able to inform us ; but, as it exists in such quantities in the earth's atmosphere, the belief is strong, especially among those who accept the nebular hypothesis, that the failure to discover it there is due to our imperfect methods, or to our ignorance of the manner in which the phenomena of the spectroscope are to be interpreted. The recent triumph of science, in the discovery of oxygen in the sun, serves to show how easy it is to overlook phenomena all the while perceptible, and gives great hope that not only nitrogen, but many other substances, will yet be found there, which have hitherto escaped observation. The fact that an element exists in the earth may not be proof that it must exist in the sun, even on the assumption that the sun is the parent of all the planets, but it is certainly strong presumptive evidence that it is also there. It is, however, much stronger proof that it existed in the general mass, as late at least as when the earth was formed out of it, and therefore in the original nebulæ. Those

evolutionists alone who are ready to accept the view here advanced of the derivation of the heavier elements from the lighter ones, in the course of the development of the system, can escape this conclusion by supposing that the substance in question was created in the planet after its separation from the central mass. But this assumption would not be required in the case of nitrogen, which remains a gas at high temperatures, and which actually exists in the nebulæ. The fact that it can be detected in the nebulæ, and not in the sun, although it doubtless abounds in both, may be accounted for by remembering that the spectrum of a nebula belongs to a different class from that of the sun, the former consisting of bright lines on a dark ground, indicating a luminous gas ; while the latter consists of dark lines on a bright ground, indicating a body having an incandescent solid or liquid interior, the rays of which pass through a cooler gaseous atmosphere. Now, this antithesis in the constitution of the two bodies may explain why certain elements existing in both may be capable of spectroscopic determination only in one, owing to peculiar conditions supplied by the special nature of the substances themselves ; for it is by no means probable that the spectroscope gives us an account of all the substances existing in the bodies examined by it.

While, therefore, there is nothing in the facts thus far discovered which is opposed to the theory that the terrestrial substances having high melting and volatilizing points have been developed out of substances which are gaseous at lower temperatures in the course of the evolution of planetary systems, these facts, so far as they bear at all upon the problem, are decidedly favorable to such an hypothesis. We certainly find such substances in our earth and in the intensely heated bodies of space, as well as in such meteoric aggregates as from time to time reach our planet, and we have not yet found any such in existing nebulæ. If the latter be conceived as gaseous, and the solar system as only a developed state of one of them, either some such hypothesis must be brought forward to explain the existence of such substances in the earth, or the original mass must be supposed to possess a sufficient degree of heat to maintain them in a gaseous form, which would be enormous, and, independently of the present theory of the origin of the nebulæ, altogether improbable. Of course, upon the view here taken, it would be wholly inadmissible. Prior to the stage in the history of a nebula at which the degree of molar aggregation is sufficient to occasion a great amount of friction among the particles, the temperature of the primary molecular aggregates must be nearly that of space, and it can rise only as increase of density and molar motion increases that friction and converts material motion into ethereal vibration. Nebulæ must therefore possess a long history, of which neither the telescope nor the spectroscope can furnish any record—the pre-luminous period—in which, of course, no gases can exist except those, like hydrogen and nitrogen, which maintain their gaseous form

under extremely low temperature. And it may be supposed that during this period other gases may exist associated with these, which, however, unlike them, are unable to sustain the successively higher and higher temperatures which the nebula acquires in its process of condensation and organization into a system, and at certain stages of this process are dissociated and resolved into aggregates of a different constitution, suited to these temperatures. Some of these latter new aggregates would naturally assume the liquid and solid forms at temperatures still high as compared with those to which we are accustomed, and constitute in the cooled-off crust of the planets the various metals and metalloids. In this manner we should have no difficulty in accounting for the existence of all the elements found on the earth, even if it were positively known that only the lighter gases were present in the parent nebulæ.

The recognized elementary substances, presenting so many different qualities, vary greatly in their so-called "atomic weights." This means simply that their molecules vary greatly in mass. The hydrogen molecule is the least known, and is therefore taken as the standard. Compared with this as unity, we find that the molecule of oxygen contains 16 times as much matter, that of carbon contains 12, that of nitrogen 14, and that of chlorine 35½ times as much. But these, instead of representing large equivalents, are, when compared with most of the metals, very small. One molecule of mercury contains two hundred times as much matter as one of hydrogen. The atomic weight of gold is 197, of platinum 197·4, of lead 207, and of bismuth 208; while the thorium equivalent, which was quadrupled in the new system, is now put at 231·4, being the largest of all the elementary units. Whether hydrogen, carbon, nitrogen, oxygen, or any of the other abundant elements having small molecules have entered into the composition of these heavy substances, is a legitimate question. The fact that these molecules are stable, whether combined or uncombined, is favorable to this view, although there may exist, as component units of the molecules of the metals, many equally stable aggregates which no human power can dissociate from their present combinations. But, if known elements were employed as components of other known elements having larger molecules, the very fact that they are elements, i. e., that we are unable to decompose them, would render it impossible to know that such was the case. Think how many hydrogen, nitrogen, or oxygen molecules might enter into the system that constitutes the unit of bismuth or of gold!

Now, it is a remarkable fact that those elements which have very high condensing points, i. e., which assume the liquid (or solid) form at very high temperatures, generally have large combining numbers, that is, large molecules; while those having low condensing points and which are gaseous at ordinary temperatures, as a rule have small combining numbers, or small molecules. To this, carbon on the one hand,

and mercury on the other, form, it is true, notable exceptions; nevertheless, the bulk of the facts sustain this law, and indicate that the genesis of those elements which we know only as solids or liquids, and which we have supposed to have taken place during the fiery ordeal through which the solar system has had to pass, is rather a process of *integration* than of subdivision, since they have much larger molecules than the gases that exist in the nebulæ, and out of which we have supposed them to be formed.

We have seen that matter, in its cosmical history, as enacted in the development of a planetary system, assumes a great variety of forms, and resolves itself into numerous specifically distinct molecular aggregates. The different substances which we know on our planet are the result of the cohesion into homogeneous masses of these different aggregates, all the constituent units of any one of these masses consisting of the same *species* of molecular aggregate. We saw reason to suppose that, at an early period in the development of the solar system (and we may infer the same for all systems), the number of distinct substances was small, and that these substances were gaseous at very low temperatures. The two abundant gases, nitrogen and hydrogen, exist in the irresolvable gaseous nebulæ, and these, doubtless, went far to constitute the original substance of our infant system. These gases, though differing greatly from each other in their atomic weights, nevertheless have small molecules compared with those of most substances now found in the earth, and which are, for the most part, either solid or liquid at life-supporting temperatures. There has, therefore, been upon the whole *increase of mass* among the molecules of substances later developed.

When we rise to the point of view which removes all distinction between elements and compounds, except the subjective one that in the former we do not know and can not prove their composition, while in the latter we can do this in so far as to resolve them into the former, we can make the further generalization that along with this increase of mass there has gone *decrease of stability* in such molecules. We are of course unable to predicate this, except inferentially, of the elements which we can not decompose, although these, doubtless, vary greatly in their relative stability, and, as before remarked, some substances which had been supposed to be elementary have already been reduced to simpler forms, and others may still be so reduced. Moreover, those which have thus yielded possess large molecules (counting that of the compound), and this should serve as an index to future attempts of a like nature. There is, for example, little hope of resolving hydrogen or carbon into simpler elements, but the reverse of the alchemist's dream may yet be realized, and gold reduced, if not to baser, at least to simpler materials.

All the known chemical compounds must be supposed to have been

developed within relatively quite recent periods. The great heat that has prevailed throughout the greater part of the history of the solar system, and which, indeed, still prevails in its nucleus, the sun, which is still $99\frac{3}{4}\frac{3}{3}$ (99·866) per cent. of the entire mass of the system, or practically the whole of it, has prevented the formation of any of the substances which we know to be composite. It is only in the comparatively minute masses which have been accidentally separated from the rest, and which, in consequence of their diminutive size, have earlier reached the point at which the radiation exceeds the generation of heat, that conditions have been produced under which these comparatively unstable substances, such as water, carbonic dioxide, and the other oxides comprising the earth's crust, could exist. In proportion as the degree of heat diminished, the capacity for more and more unstable substances increased. The earliest compounds were those in which silicon, potassium, sodium, magnesium, etc., combine with oxygen, several of which were, from their great stability, long regarded as elementary. Then came a variety of acids, alkalies, and salts, together with compounds of the metals. Later, as the temperature still further lowered, the oxygen was enabled to seize the hydrogen and form the gaseous protoxide, steam, which at a still later period, when the temperature of the earth's surface fell below 100° Centigrade, condensed into water. Long prior to this, carbonic acid had been formed, and, doubtless, constituted at that time fully one half of the earth's atmosphere. The vast amount of free carbon now existing in the earth, and, still more, that which is fixed in the chalk and limestone formations, all of which must have formerly existed in the atmosphere in the form of carbonic-acid gas, indicates that the above estimate is probably far too low.

All the compounds thus far referred to, and all others having a certain degree of stability, must have been first formed at a period of considerable heat, the dissociation point of all compounds having been estimated at 6,000° Centigrade; although this, doubtless, varies for different compounds as greatly as do the condensing points of different gases. But there are, besides, many compounds which are continually forming at such temperatures as now prevail on the surface of the earth, and most of these are very much more unstable than those last mentioned. The elements which chiefly enter into such compounds are oxygen, nitrogen, hydrogen, and carbon, all but the last named of which are gaseous at ordinary temperatures. The substances of this nature with which we are familiar are known as *organic compounds*, and such as we see are, in fact, the products of organized beings from the different parts of which they are obtained. But this process should not be regarded as any less cosmical than that by which the rocks or the metals have been evolved out of primordial matter.

Time forbids the further following out of this series of steps in the development of existing forms of matter, but it will be readily per-

ceived how, if this train of reasoning be sound, the inorganic is directly linked to the organic world, just as the imperceptible forms of matter were shown to be linked to its perceptible forms, and the elementary states to the composite states, in one continuous and unbroken chain. It remains to point out to what extent the hypothesis here advanced, of the probable genesis of the chemical elements, is found to be in harmony with the recent discoveries which Mr. J. Norman Lockyer has made by means of the spectroscope in the domain of chemistry. In endeavoring to do this in the briefest manner possible, let us reproduce the following diagram drawn up by him :

Hottest stars,	Lines of	H	+	Ca	+	Mg					
Sun,		H	+	Ca	+	Mg	+	Na	+	Fe	
Cooler stars,		—		—		Mg	+	Na	+	Fe	+ Bi + Hg.
Coolest,	Fluted bands of	—		—		—		—		—	—, etc.

Modified in the arrangement only to suit the present discussion, the first part of this diagram may be presented as follows :

Cooler stars.

Sun.

Hottest stars.

1	24	40	23	56	200	208
H +	Mg +	Ca +	Na +	Fe +	Hg +	Bi
1	12	20	23	28	100	208

The figures placed over the symbols are the respective atomic weights of the elements according to the new system, those placed beneath being the same according to the old system. Transposing calcium and magnesium merely for the sake of symmetry, their position being indifferent, since both appear in the hottest stars, we find that with a single exception, that of sodium, if we take the new system, and without exception, if we take the old system, the atomic weights increase as the temperature of the body diminishes. To what extent this result may be accidental it is of course impossible to say, but, so far as it may have any scientific significance, it constitutes an interesting confirmation of the theory that the heavier elements with large molecules have been developed out of the lighter ones with small molecules during the progress of the condensation and refrigeration of the heavenly bodies, and according to which, as above pointed out, those possessing the largest equivalents would be last formed and gradually pass into the known compounds by a corresponding gradual decrease of stability, these latter to be succeeded in turn by the evolution of organic aggregates which ushered in the era of life.

Generalizing from all that has been said, we may divide the known

forms of matter into the three following classes, with the accompanying definitions :

1. Chemical Elements.—Substances whose molecules are composed either of those of other chemical elements of less atomic weight, or of such as are too low to be capable of molar aggregation, and therefore imperceptible to sense : formed during the progress of development of star-systems at temperatures higher than can be artificially produced, and hence too stable to be artificially dissociated.

2. Inorganic Compounds.—Substances whose molecules are composed of those of chemical elements or of other inorganic compounds of lower degrees of aggregation : formed in the later stages of the development of planets at high but artificially producible temperatures, and therefore capable of artificial decomposition ; and constituting the greater part of the solid crust of cooled-off bodies, their liquid and a portion of their gaseous envelope.

3. Organic Compounds.—Substances whose highly complex and very unstable molecules are composed of those of chemical elements, inorganic compounds, or organic compounds of lower organization : formed on the cooled surfaces of fully developed planets at life-supporting temperatures.

ONLY A VINE-SLIP.

By T. G. APPLETON.

THE world's life is one long day, in which events strike the hours. The hours strike, time moves on, till another stroke marks an advance which could only be that of the present moment, and to which all the minutes of the past have contributed. I seemed to hear that clock of the ages strike, the other day at my table, when a charming young Frenchman was explaining why he had come to America. It is humiliating to man, haughty in his mastery of this world, to find a successful antagonist, the least of creatures, microscopically small, and nameless often, till the baffled husbandman is obliged to write it in Greek or Latin characters upon the banner of his conquering foe. The *Phylloxera* is mightier than a German army ; for the latter, once satiated, goes home, but the former apparently stays for ever. The Egyptians are again upon us ; the plagues of Egypt, and perhaps, what is worse, the plagues of America, move across the world, devastating as they go. The contagion of evil seems to outrun that of beneficence in an unfair proportion. Creatures unconscious of what they do, which the microscope barely discovers, terrify whole nations, and give the lie to the arrogance of man. Somewhat as the old thought is now super-

seded, the old faith of the mind sapped, by the maggot in the brain which breeds doubt and, denial, so in these latter days, the old beldam Earth breeds *oïdium* which blights, the phylloxera which destroys. It was the phylloxera which interested my young Frenchman. He had just come from California, after sending home countless *boutures* (vine-slips) to his father, a *vigneron* of Burgundy. It is found that these bits of vine, planted in France and then grafted with the vine of the district, will resist in most cases the phylloxera, and so save the vine-yard. It was when hearing this from my young *vigneron* that I seemed to hear that earth-clock strike. The sound I thought was braided of two murmurs where joy and sorrow blended. "Yes," I said to myself, "youth is a good thing, and how beautiful it is to see it sustaining the decrepitude of age!" How proud, thought I, should America be to see her democratic blood mingled with to sustain the princely lives which Bacchus honors! American girls wear the straw-berry-leaf and sit not far from the throne itself. And how like this is the marriage between the *parvenus* of California and those princely ones whose *etiquette* gleams at royal boards! But how are the mighty fallen! The imperial house of Clos Vougeot is in the dust, and many another lordly house besides. A friend of mine, an expert in the science of wine, crowned his wealth by the purchase of this imperial Clos (field) of Vougeot. This little field, the most precious for its extent in France, a true Field of the Cloth of Gold, whose grape is the highest expression of God's beneficence through the vine he gave us, has a flavor, perfumed, modest, tasting of the violet, which separates it from the crude and harsher vintages as a gentleman is distinguished among roughs. This favorite of the earth, this consummate flower of France, Providence shall not long allow to lie perishing in the dust. And it is the democrat who shall fly to the rescue of this scion of an imperial house. For the world of epicures will not be deprived of its dainties; and it is no more than justice that America should heal the wound she makes, for it is confidently asserted that vines from America, imported into the south of France, brought the phylloxera with them. But this is only guess-work; there is a mystery in the modern sudden distribution over the world of insects and weeds which is not understood. It can not be watched, because it is not suspected, and secretes itself as part of a freight fetched for quite another purpose. Mrs. S. C. Hall has told us how, for ten years before, the weed *Anacharis alsanastrum* spread with frightful rapidity over the inland waters of England, choking ponds and rivers, as may be seen in the Serpentine of London, the germs of which plant were supposed to have been secreted in imported timber. I have recently, however, read that this plant was dying out, apparently finding its environment unsatisfactory. It is interesting also to hear of a process, the reverse somewhat of California's grape-cure, namely, how the robust weeds of England devour, as Britons do the natives, the weaker weeds of Australia. So have we

devoured and displaced the Indians ; and some think the plucky English sparrow, after whipping all birds of its weight, is destined in the future to take their place. The law which permits such strange invasions of foreign seeds and insects is evidently not a demand for them in a place where they strike. It is no part of a scheme of use or beneficence ; they are a law unto themselves, and attach where they can find a foothold. They ravage as a fire does where the air or the earth is ready to flame like tinder, and they challenge man, as yet victoriously, to match his newly acquired knowledge, his microscope, and his chemistry, with the vivacity of their attack. The renowned M. Pasteur vainly fights for his silk-worm, nor is the battle yet decided ; soon all the resources of science, all the skill of the naturalist, will be needed to beat back the invading armies. Man has made, in so much, Nature his slave. He bridges the ocean, he pierces the Appian barrier, he trains the lightning to fetch and carry for him, he pierces stellar space, he analyzes the sun, and, when he feels an obstacle, he forces his way ; neither the sands of Suez nor the marshes of Panama delay him ; but he stands baffled before his invisible enemy. A breath of air can poison his cities, or devastate his harvests. Nature thus comes back with an unexpected boomerang. *Entre nous, deux maintenant.* And, though proud man clearly anticipates his final triumph, cholera and yellow fever come and go at their own sweet will. The Colorado beetle journeys comfortably to visit foreign parts. A new plague of locusts, the grasshopper of the West, leaves famine behind him as he moves, and even the Gascon wine, into which the nose of Thackeray once dipped, feels an unholy presence, the blight of a new disease.

But there are other things which fly on the wings of the wind besides the seed-capsule which nourishes, the flower-germ which ornaments ; thought also goes with them as they fly. Never was it so volatile, not as once hoarded in some vast brain, packed into folios by the weary hand, buried in the silence of cloisters through long ages, and at last fructifying suddenly in a thousand lives. Thought now is ever active, omnipresent ; an idea now germinates in San Francisco, and a week later is stale in India. The solidest creeds get their edges frittered away by these clouds of passing thought. Custom secures a little the stability of things, but much of it is automatic—the heart is gone out of it. The monarchist is often a better democrat than his American brother, the priest who intones his service is tampering with agnostic infidelities, the Arab sheik presents you with his photograph, and the King of Siam adds a lift to his palace. There is hardly such a thing as discussion ; assertion usurps the hour, and there is no reply. Everybody could be on either side of the questions which once distracted the world ; and as we see the Prince of Wales over a cigar, trifling with democratic notions, the old noble humbled before the feudality he represents, the priest meshed in a network of hypocrisies

from which he would gladly escape—when we see these things, are we not reminded of the phylloxera which can taint the goblet in the hand of a king, of the secret foe which silently saps the health of cities, and that confusion of life and death, which, flying upon the wings of the wind, affronts the stablest security and makes a jest of human conservatism?

THE METEORS OF NOVEMBER 13TH–15TH.

By Professor DANIEL KIRKWOOD.

WHEN the coincidence between the orbits of the November meteors and the comet of 1866 was first clearly established a few years since, it was supposed by astronomers that the so-called Leonids formed a single cluster, diffused through an arc of such length as to require three or four years to make its perihelion passage. The meteoric period was shown by Professor Newton, of Yale College, and J. C. Adams, of Cambridge University, to be thirty-three and one fourth years. Consequently, no further displays were expected from this stream till about the close of the century. But in "Nature" for June 3, 1875, numerous facts were given, all indicating the existence of a second group, less dense in its structure, and preceding the principal swarm by twelve or thirteen years. Again, the large number of meteors seen in 1879, taken in connection with the fact that, according to Humboldt, meteors were seen in unusual abundance just thirty-three years before, viz., in 1846, suggested the probable existence of a third and perhaps still smaller cluster, passing its perihelion about 1879–'80. It was felt to be important, therefore, that in case any considerable number of meteors should be visible this year at the November epoch, the shower should be observed and the facts recorded. Accordingly, I requested Professor D. E. Hunter, Principal of the Washington (Indiana) High School, to keep watch on the mornings of November 13th, 14th, and 15th. Professor Hunter has made a comprehensive report, which I have somewhat abridged in the following statement. The morning of the 13th was cloudy, and on the 15th the moon shone brightly till daybreak. The watch was consequently restricted to the morning of the 14th. Four observers were occupied from $3^h\ 45^m$ to $5^h\ 45^m$—precisely two hours. The position was on a hill south of Washington, where the view was unobstructed, except on the south. One hundred and sixteen meteors were counted, ninety-one of which were conformable to the radiant in Leo. During the first hour the atmosphere was hazy and the moon interfered with the observations. The second hour was clear and moonless. The following table includes only Leonids, giving the number counted in every five minutes:

3h. 45m. to 3h. 50m., 1 meteor.						4h. 45m. to 4h. 50m., 3 meteors.					
3	50	"	3	55	1 "	4	50	"	4	55	6 "
3	55	"	4	0	0 "	4	55	"	5	0	6 "
4	0	"	4	5	0 "	5	0	"	5	5	7 "
4	5	"	4	10	0 "	5	5	"	5	10	1 "
4	10	"	4	15	0 "	5	10	"	5	15	2 "
4	15	"	4	20	0 "	5	15	"	5	20	7 "
4	20	"	4	25	5 "	5	20	"	5	25	7 "
4	25	"	4	30	0 "	5	25	"	5	30	12 "
4	30	"	4	35	4 "	5	30	"	5	35	11 "
4	35	"	4	40	0 "	5	35	"	5	40	5 "
4	40	"	4	45	4 "	5	40	"	5	45	9 "

Table showing the same Meteors as above by the Quarter-Hour, Half-Hour, and Hour.

3h. 45m. to 4h. 0m., 2						4h. 45m. to 5h. 0m., 15					
4	0	"	4	15	0 } 2	5	0	"	5	15	10 } 25
4	15	"	4	30	5 } 15	5	15	"	5	30	26 } 76
4	30	"	4	45	8 } 13	5	30	"	5	45	25 } 51

Moon during first hour.

No moon second hour.

REMARKS.—1. The maximum was at 5^h 30^m, when five Leonids were seen in one minute.

2. The shortest path—two degrees—was that of a meteor nearly stationary, seen in Leo at 5^h 18^m. The longest—forty degrees—crossed Ursa Major at 5^h 20^m.

3. The average length of path during the first hour was six degrees; in the second, about seven; the increase being probably due to the absence of moonlight.

4. At least three distinct meteoric swarms move in the track of Tempel's comet (1866 I.). One has just passed or is passing perihelion; the second will pass about 1887–'88; and the maximum group about the close of the century.

5. The meteors on the morning of the 14th inst. were more numerous than those of the August shower; a fact quite remarkable when it is remembered that it is fourteen years since the great display of the principal cluster.

6. The estimated periods of the comet and the meteor groups of the Leonid ring are as follows:

Tempel's comet	33·176 years.
Group A	33·250 "
Group B	33·333 "
Group C	33·500 "

The last is derived from the showers of 1813, 1846, 1847, 1879, and 1880.

7. Oppolzer's period of Tempel's comet, as given above, is perhaps too short. If this body was a return of the comet of 1866, its mean period is 33·283 years—very nearly the same as the meteoric periods.

8. It is sufficiently obvious that we have yet much to learn in regard to the constitution of the Leonid ring, and that future observations from the 13th to the 15th of November may probably result in important discoveries.

BLOOMINGTON, INDIANA, *November* 25, 1880.

PREHISTORIC SCIENCE EN FÊTE.

TO the uninitiated an "International Congress of Prehistoric Anthropology and Archæology" may seem a formidable affair, where no more cheerful entertainment than a feast of dry bones could be allowed, and where a member indulging in a joke would be instantly called to order. Those who attended the late meeting of this Congress at Lisbon know better. They know that under cover of their imposing title this scientific Congress can give itself up to sociability, and even levity, without imperiling its dignity. They know that this assembly of men, representing the scientific world in nearly every country in Europe, has as human an idea of enjoyment as the most ordinary mortals who have never even heard of the Neanderthal skull, and to whom the term palæolithic or quaternary man calls up no vision of cave-bears or hairy mammoths, living hob-and-nob, so to speak, with our flint-using ancestors.

Let us follow the fortunes of the Congress, the idea that the typical Dryasdust flourishes among its members being dispelled. The first unofficial *séance* may be said to have taken place at Almorchon, a junction half-way from Madrid, where all the scientific pilgrims, more or less tired and dusty, made a rush at the buffet to get what food was to be had. Those who had been traveling from Madrid since the previous evening and those who had taken a preliminary tour through Andalusia here met, and instantly there was a Babel of tongues—German, Italian, French, and English. Only Spanish was not to be heard, so that, but for the tropical heat of the sun and the Sahara-like aspect of the surrounding country, one would hardly have realized that one was in the Peninsula. Friends were inquiring how each other's work had sped since the meeting four years ago at Buda-Pesth, or that of Stockholm two years earlier. Scientific men who had never met before, and who only knew each other by books or letters, were being "enchanted to make each other's acquaintance" in the best French they could muster. Some were deploring in hushed tones the great loss just sustained by anthropology in the death of M. Paul Broca, who was to have been present at Lisbon. Here was the universal favorite, M. de Quatrefages, of the French Institute, in a gray suit and wideawake, looking more like a genial English geologist than a French *savant*,

shaking hands with all. Professor Virchow, talking slowly to a learned *confrère* on the one hand, and M. Henri Martin, deep in an Iberian controversy, on the other. Here was a spruce and speckless Frenchman, as fresh and bright as in his native Paris; there, a crumpled German, bearing evident traces of a night in the train. After all, there was ample time to exchange greetings and compliments, as well as for the more important business of eating, as the proverb, "Hurry no man's cattle," is also applied to trains in Spain. A Spaniard in a hurry was the one curiosity no member of the Congress was fortunate enough to light on, although every facility to see all the rarities of the country was politely accorded them.

At last the excruciating sound of the whistle summoned all to ensconce themselves in their snug corners of the carriages again, and only at daybreak next morning—on Sunday, September 19th, to be exact—did this first detachment of science, coated with a yet thicker layer of dust, arrive at Lisbon, after thirty-three long hours from Madrid.

Until last year a direct train accomplished this journey in ten hours less time; but Spain, tenacious of old traditions, suppressed that train as savoring too much of progress, and consequent Nihilism and dynamite.

All that Sunday the newly-arrived foreigners talked of nothing but the lovely position of Lisbon, with its many hills and broad Tagus. They much admired the great reservoir of the famous aqueduct with its tail sixteen miles long, and also the cats with no tails at all. Lisbon literally swarms with cats, and not a few have their ears and tails cropped; this is a scientific note made by a *savant* on the spot. There were also many speculations among this festive company as to whether they should get as much dancing as at Pesth, where—let not this confidential disclosure damage their scientific reputation—in the course of one short week did they not fit in three dances, one of which was extemporized in the waiting-room of a railway-station, in returning from a ghoul-like expedition, undertaken for the purpose of rifling some dozen Bronze-age graves? Such was their heartless levity! After this disclosure it will be no shock to hear that, on the eve of their serious work at Lisbon, most of this frivolous body patronized the bull-fight. In extenuation, it must be admitted that a Portuguese bull-fight is not, like the Spanish, a public shambles and knacker's yard, but a bloodless trial of dexterity, from which the gorgeous cavaliers, on their splendid Andalusian horses, come out unharmed; and the bull, whose horns are encased in leather-and-iron gloves, is driven out very happily among a herd of tame oxen, whose business—and well the sagacious animals understand it—is to decoy him out of the arena.

The following day there was the impressive inauguration of the Congress by the King himself. The hall provided for the *séances* is the library of a suppressed monastery, where all the old calf and vel-.

lum bound books lining the walls seemed quite in harmony with the dryness of some of the discussions, though the way our authorized ancestor Adam was unanimously ignored might have made the worthy old monks' hair stand on end. At one end of this hall a great throne was erected, with ermine and the Braganza arms all complete. Opposite a band was stationed; in the gallery around admiring natives were congregated. All the male representatives of science were in evening dress, *gibus* in hand, and resplendent with orders. M. Capellini, of Bologna, a great man though small of stature, was noticeable for the number of his decorations. With four full-blown crosses and ribbons, besides a dozen lesser stars glittering on his shirt-front, he was a gorgeous sight. The only English member yet arrived was conspicuous for the unrelieved black and white of his attire.

With royal punctuality, precisely at one o'clock, the band struck up the national hymn, and their Majesties entered: Dom Fernando, the tall Dowager King Consort (if that is his official title), and Dom Luis, the dumpy reigning King, his son. Every one, it is to be hoped, knows Thackeray's "Rose and the Ring," and if they do not they should know it, so it is needless to describe their royal highnesses further than by saying that the courteous Dom Fernando is the image of the old king in that charming tale, and the accomplished Dom Luis its hero Prince Bulbo in person. There was no mistaking the fact, the immortal Bulbo stood before us—on tiptoe mostly, to add height to his august presence—and we were duly impressed accordingly. With royal patience he and his father sat under their ermine awning, listening to inaudible speeches, with *homme miocène* as their refrain—what a long course of boring it must take to teach any one to bear it so patiently! who would choose to wear a crown?—and then with royal courtesy they descended from their eminence to be introduced to the leading members present. That over, they had to begin again with the Literary Congress, whose session here also opened that day; while the archæologists and anthropologists escaped to examine the bony and stony treasures of a museum illustrating these sciences, established in the same building. In this arid region many warm discussions as to the antiquity of man took place, and as to how far some undetermined flakes of flint, with dubious bulbs of percussion, found in a questionable stratum, went to prove his existence in Tertiary times. This was the main question of the Lisbon session.

Two days afterward an excursion was made to Otta, the abovementioned haunt of this doubtful Tertiary being, to test the value of the evidence. By 6 A. M. all on science or amusement bent were steaming out of Lisbon. An hour later all had left the special train, and were distributed among twenty-two carriages and omnibuses, drawn, as a rule, by four fine mules, the manners and customs of which were curious and unexpected. The leaders would suddenly bolt round and stare at their scientific load with superhuman curiosity. It re-

quired many of these wayward beasts to drag the carriages through the four or five inches of dust underfoot. After three hours of such wading, a little sheltered from the blazing sun by the clouds of dust the mules raised, Otta was reached. Otta, or rather a sandy wild with a thin growth of foot-high dwarf-oaks, some miles farther on, is the spot our Tertiary phantom is supposed to have selected for his dwelling. There was a lake there in those days. No one would be predisposed to acknowledge as an ancestor either man or ape capable of displaying such bad taste in his choice of a home; for in Portugal beautiful and wooded retreats abound, so there was no excuse for settling in a bare desert—except perhaps the fishing. However, all dutifully hunted for this creature's remains; but only one flake, near the surface, was found by an Italian, Signor Belucci from Rome, and that caused hardly less excitement than the discovery of a new gold-mine.

But the dryness of the day and subject was exhausting, even to those most affected by the *fièvre tertiaire*, and all readily abandoned the dust of ages and flocked into a tent, a lodge in that vast wilderness, which seemed to have come there by enchantment. Due justice was done to the sumptuous breakfast prepared, for science does not impair the appetite, and then followed endless toasts. The health of the foreign members having been proposed, a representative of each nation, French, German, English, Italian, Spanish, Danish, Swedish, and Slav, returned thanks in widely varying accents for their hospitable reception in Portugal. M. de Quatrefages was by far the best orator, and the President, Senhor João d'Andrade Corvo, spoke well. After much time, wine, and breath had been expended, a practical Englishman, who meant work, and was not broken in to foreign dilatoriness, proposed as a final toast *Au silence et au travail.* The hint was taken, and hammers and sunshades again put in requisition, but again with no decisive result. Two of the ladies of the party, escorted by two gallant Frenchmen, made the difficult ascent of a neighboring steep hill, to look down disdainfully on the worthy archæologists grubbing below like ants, and following as useless a quest as those minute busybodies seem to indulge in as a rule. When it is mentioned that the thermometer stood at 96°, it would be superfluous to indicate the nationality of the fair climbers.

But for an opportune vineyard passed on the return journey, all Europe might have been bereaved of her science, as the great expedition nearly died of thirst. Anthropology would have been nipped in the bud, and archæology would have returned to the dust, had not a supply of grapes averted the awful calamity.

Next morning, Wednesday, primeval cannibalism was the subject of debate, but "long pig" was not discussed for dinner, as might have been expected, thanks to good Portuguese cookery.

The day following the gay assembly were abroad again, going to Santarem, where they were received with flags and rockets, welcomed

by the mayor, and escorted to the kjökkenmöddings, their goal, by hundreds of picturesque mounted peasants. Here a grand display of skeletons, and of the refuse of the meals by which these frames were nourished, rejoiced their eyes; and later the speechifying, etc., were gone through with as much enjoyment as before.

On Saturday the two kings honored the *séance* with their presence to hear the great Tertiary debate, which M. Mortillet, of the Musée St. Germain, opened with needlessly elementary instruction as to the formation of flakes, and asserted his belief in the disputed ancestor's existence in a speech lasting an hour and a half.

> "He argued high, he argued low,
> He also argued round about him."

An Englishman, known, from his habitual demand for evidence, in the foreign scientific world as *le petit St. Thomas*, answered him with geological and other objections. He said that no flakes indubitably found in these Tertiary beds were of unmistakable human manufacture, but were such as might be due to natural forces; and insisted on the necessity of strong proof before accepting, as an established fact, man's existence at a time so widely remote from ours—a time when the hipparion was the nearest living representative of the horse, and since which the whole fauna had almost completely changed. Then St. Thomas wound up by declaring that, though for twenty years he had upheld the antiquity of our race, as proved by the discoveries at St. Acheul and in other old river-valleys, and it therefore ill became him to dispute it now, he could not be satisfied to rest his pedigree on a single bulb of percussion.

M. de Quatrefages, who does not believe in evolution as applied to the human race, declared for Miocene man. So did M. Capellini, who had already brought some pet whalebones, found in the marine beds of Italy, before the Congress at Pesth; which bones he believes to have been scored in Miocene days by wrought flints. Others venture to think the marks may be due to the teeth of fishes rather than to human agency. Virchow was dubious. Most suspended their verdict until there should be more conclusive evidence, so the resolution of this great question was adjourned to the next session.

Of course, one excursion was to lovely Cintra, and to Dom Fernando's picturesque Penha palace perched on a peak there, with its castellated walls and little gilt domes. It was grand to see *savants* gravely riding the tiny donkeys down perilously deep descents. However, thanks more to the sure-footedness of the beasts than to the skill of the riders, no one came to grief. The views at Cintra over the rocky peaks, great pine-woods, and long-stretching plain, with the misty Atlantic as an horizon, are beautiful, and the Moorish remains there are most curious. That evening the real King gave a ball at Cascaes to the Congress, but, in spite of the courtesy of the hosts, the dancing

was less gay than at Pesth, not being *impromptu*. The supper was the great feature of the entertainment. Footmen in gorgeous liveries brought in trays of tempting delicacies, fish, flesh, fowl, and good red wine, to which all were prepared to do justice after a hard day's work. Only there were no plates, knives, forks, or other appliances of civilization. Nothing but large wooden toothpicks.

All hang back, eying longingly the dainties good manners forbade them to seize, and watching what course royalty would pursue.

But the court, nay, royalty itself, unhesitatingly took a toothpick, dug it into the chosen morsel, poised it a moment in the air, and it was gone. Thus emboldened, all possessed themselves of these handy instruments, and dug in their turn, roving and sipping like bees, though all with inward misgivings as to whether they had been spirited away suddenly to China or some other Eastern haunt of the primitive chopsticks. On after-inquiry it was learned that in all large court assemblies these toothpicks were put in requisition, as it was feared that silver forks might be pocketed by the guests. It was neither as an insult to scientific honesty, nor a compliment paid to the archælogical tastes of the Congress, that such primeval weapons were used.

The day after this last and most foreign experience nearly all these learned birds of passage had flown—some to the wintry north, others to the sunny south, all bearing a grateful remembrance of a charming week, and of the warmth of Portuguese hospitality; all speculating as to when and where would be their next merry meeting.—*Fraser's Magazine.*

SKETCH OF COUNT POURTALES.

BY the death of this able naturalist, in the full maturity of his powers, American science has sustained a great and irreparable loss. We give a likeness of him from the only photograph we could find, and, as no biography of him, that we are aware of, has been written, we are indebted for the materials of this statement to such fragmentary notices as have been furnished to the press since his death.

Louis François de Pourtales was of the Swiss nationality, and was born in 1823. He belonged to an old family, which had branches also in France, Prussia, and Bohemia. He was educated as an engineer, but showed from boyhood a predilection for natural history. He became a student of Professor Agassiz, and was one of his favorites, accompanying him to America in 1847, and joining in his early labors, first at East Boston, and subsequently at Cambridge. In 1848 he entered the Government service in the department of the Coast Survey, and continued in it many years. Professor Theodore Lyman, writing of Pourtales in the "Boston Advertiser," says:

"His talents and industry made him a man of mark, to whom was intrusted much work that required original thought. Especially did he show interest in the problems of deep-sea soundings and the structure of the ocean-bottom, an interest that led to profound observations on the physical geography of the Caribbean Sea and the Gulf Stream. His papers on this subject were of the first order, and established his reputation in Europe as well as in America.

"By the death of his father, he succeeded to the title, and received a fortune which enabled him to devote himself wholly to his favorite studies, and to do much in continuing the great work of Louis Agassiz. Appointed keeper of the Museum of Comparative Zoölogy, he gave himself, with untiring devotion, to carrying out the arrangement so laboriously planned by his friend and master. Dividing the task with the curator, Alexander Agassiz, he pushed forward his part of the work with the easy power of a strong and highly-trained intellect. Every day and all day at his post—now pursuing special investigations, and now directing the details of the museum—he was the model of an administrative officer.

"He had not an enemy, and could not have had one; for, although firm and persevering in temper, he possessed the gentleness of a child and a woman's kindness. His modesty amounted almost to a fault; and people wondered why a man who was master of three languages should talk so little. But with intimate friends he would speak freely, and never without giving information and amusement. His range of learning was very wide, and his command of it perfect; nor was it confined to mathematics, physics, and zoölogy. He did not scorn novels and light poetry, and was knowing in family anecdotes and local history. Indeed, it was a saying in the Museum that, if Count Pourtales did not know a thing, it was useless to ask any one else."

Professor Alexander Agassiz writes to "Nature" as follows: "M. Pourtales was the pioneer of deep-sea dredging in America, and he lived long enough to see that these expeditions had paved the way not only for similar English, French, and Scandinavian researches, but had led in this country to the Hassler, and finally to the Blake Expeditions, under the auspices of the Hon. Carlile P. Patterson, the present Superintendent of our Coast Survey. On the Hassler Expedition from Massachusetts through the Straits of Magellan to California, he had entire charge of the dredging operations; owing to circumstances beyond his control, the deep-sea explorations of that expedition were not so successful as he anticipated.

"The materials of the different deep-sea dredging expeditions above mentioned had been chiefly deposited at the Museum in Cambridge, and were thence distributed to specialists in this country and in Europe. A large part of the special reports upon them have already appeared. M. Pourtales reserved to himself the Corals, Halcyonarians, Holothu-

rians, and Crinoids. A number of his papers on the deep-sea corals of Florida, of the Caribbean Sea, and of the Gulf of Mexico, have appeared in the Museum publications. He had begun to work at the magnificent collection of Halcyonarians made by the Blake in the Caribbean Sea, and had already made good progress with his final report on the Holothurians. The Crinoid memoirs published by him relate to a few new species of Comatula and to the interesting genera Rhizocrinus and Holopus.

"The titles of his memoirs indicate the range of his learning and his untiring industry. His devotion to science was boundless. A model worker, so quiet that his enthusiasm was known only to those who watched his steadfast labor, he toiled on year after year without a thought of self, wholly engrossed in his search after truth. He never entered into a single scientific controversy, nor ever asserted or defended his claims to discoveries of his own which had escaped attention. But, while modest to a fault and absolutely careless of his own position, he could rebuke in a peculiarly effective, though always courteous, manner ignorant pretensions or an assumption of infallibility.

"Appointed keeper of the Museum of Comparative Zoölogy after the death of Professor Agassiz, he devoted a large part of his time to the administration of the Museum affairs. Always at his post, he passed from his original investigations to practical details, carrying out plans which he had himself helped to initiate for the growth of the institution. As he had been the devoted friend of Professor Agassiz's father, he became to his son a wise and affectionate counselor, without whose help in the last ten years the Museum could not have taken the place it now occupies. If he did not live to see the realization of his scientific hopes, he lived at least long enough to feel that their fulfillment is only a matter of time. He has followed Wyman and Agassiz, and like them has left his fairest monument in the work he has accomplished and the example he leaves to his successors."

H. N. Mosely communicates to the same journal the following observations on Pourtales's scientific work: "Almost from the commencement of his connection with the United States Coast Survey he deeply interested himself in deep-sea questions, and some of the earliest observations on the nature of the deep-sea bottom and of Globigerina mud were made by him. He wrote on the structure of Globigerina and Orbulina, and described the occurrence of the small Globigerina-like shells bearing spines in the interior of certain Orbulinæ, which he concluded were the swollen terminal chambers of Globigerinæ containing young in progress of development. The first step in deep-sea investigation in the United States was taken by the late Professor Bache on his assuming the duties of the United States Coast Survey in 1844, when he ordered the preservation of specimens brought up by the lead. Every specimen was carefully preserved and labeled,

and deposited in the Coast-Survey Office in Washington. The microscopical examination of the specimens was commenced by the late Professor J. W. Bailey, and after his death this work passed into the hands of Pourtales, who devoted his time to it in the intervals of other duties. That most important deposit, Globigerina mud, was first discovered by Lieutenants Craven and Maffit, U. S. N., during Gulf-Stream explorations in 1853. In 1867 systematic dredging in deep and shallow water was commenced on the assumption of the superintendence of the Survey by Professor B. Peirce, who ordered the dredging. At the suggestion of Louis Agassiz, dredgings were made down to a depth of one thousand fathoms. In Professor Agassiz's report, one of the richest grounds for deep-sea corals, lying off Cape Florida, was named Pourtales Plateau. In 1871 Pourtales published what is probably his best-known work, namely, his "Deep-Sea Corals" ("Illustrated Catalogue, Museum of Comparative Zoölogy," Harvard, No. iv), a most excellent memoir containing valuable disquisitions on the affinities of various genera, and excellent notes on the geographical distribution of the species and the nature of the bottom on which the dredgings were made.

"Count Pourtales's name is indissolubly connected with deep-sea zoölogy by means of the genus Pourtalesia, named after him. Pourtalesia, a sea-urchin, one of the Spatangidæ allied to Ananchytes, was found by the Challenger Expedition to be one of the most ubiquitous and characteristic deep-sea animals. Numerous species of the genus new to science were obtained by the expedition in deep water, some of them being of most extraordinary shapes. In conclusion, it need only be added that Count Pourtales's kindness and good-nature were as much appreciated by English naturalists as elsewhere. He was most generous, always ready to give advice to naturalists working in the same most difficult field as himself, to supply them with specimens for investigation, and to discuss in the freest manner, with perfect impartiality, any question of systematic arrangement. He will be regretted by many friends in England, to which he paid frequent visits on his way to his native country, his last visit having been made in the spring of the present year."

Count Pourtales was a man of a strong frame, a vigorous constitution, and a temperate mode of life, which gave hope of a long period of usefulness. But he was attacked by a fatal internal disease, and, after several weeks of great suffering, heroically endured, he died at Beverly Farm, in Massachusetts, on July 17, 1880, aged fifty-seven years.

EDITOR'S TABLE.

THE FORCES OF HUMAN PROGRESS.

THE interesting volume of Mr. Henry George, on "Progress and Poverty," was discussed in the "Monthly" upon its first appearance, though rather for the purpose of making it known than of criticising it. But, as it has now become a success, and passed to a fourth and cheaper edition, it becomes desirable to look more closely into some of its positions. It is not, however, the author's doctrine of the great and growing evils of land monopoly, nor the remedy which he proposes for these evils, nor the economic views he has put forth, that now concern us. The first nine books of his treatise are devoted to these topics, but in the tenth and concluding book he takes up another and a larger subject. He here discusses "the law of human progress," and opens the weighty question of the philosophy of all social and political reform; and with the views here advocated we can not at all agree.

The argument of Book X, though not strictly a part of the main thesis of the volume, grows naturally out of it. Having traced certain great social evils to their root, and shown, as he believes, how they may be escaped, he was of course urgent that his measure should be forthwith adopted, and the good it promises secured. Impelled to write his book by realizing the squalid misery of a great city, which appalled and tormented him, he was driven by the whole force of his sympathies to find some plan of removing it, and when found he was naturally eager that it should be applied. But he was here confronted by the school of thinkers which now teaches that genuine and permanent social ameliorations must be far more gradual in their operation than has formerly been supposed; that the progress of human society is but part of a larger and very deliberate progress in the course of nature, and which takes place through the agency of natural laws to a great extent independent of the volitions or intentions of men. They teach that man himself is a product of progress, and has been so developed and transformed by nature that he at last begins to be capable of understanding nature's method, and of consciously taking part in the progressive work.

Mr. George takes issue with this whole theory, and coolly rules nature out of the entire business. He denies "that human progress is by a slow race development." He says, "We have seen that human progress is not by altering the nature of men," and again, "Human progress is not the improvement of human nature."

He further denies "that progress is by hereditary transmission," and affirms "that human will is the great factor." The view to which he holds is thus briefly intimated: "Mental power is, therefore, the motor of progress, and men tend to advance in proportion to the mental power expended in progression—the mental power which is devoted to the extension of knowledge, the improvement of methods, and the betterment of social conditions. Now, mental power is a fixed quantity—that is to say, there is a limit to the work a man can do with his mind, as there is to the work he can do with his body; therefore, the mental power which can be devoted to progress is only what is left after what is required for non-progressive purposes. . . .

"These non-progressive purposes in which mental power is consumed may be classified as maintenance and conflict. By maintenance, I mean not only

the support of existence, but the keeping up of the social condition and the holding of advances already gained. By conflict, I mean not merely warfare and preparation for warfare, but all expenditure of mental power in seeking the gratification of desire at the expense of others and in resistance to such aggression. . . .

"Association in equality is the law of progress. Association frees mental power, for expenditure in improvement and equality (or justice or freedom, for the terms here signify the same thing, the recognition of the moral law) prevents the dissipation of this power in fruitless struggles. Here is the law of progress which will explain all diversities, all advances, all halts, and retrogressions."

Nothing can be more unsatisfactory than this. It sounds like last-century talk, before science had entered upon the investigation, and ignores a whole continent of facts that have been upheaved during the last two or three generations, and which are fundamental to any theory of human advancement. These scientific revelations force upon us the question of the improvement of man in his earlier stages, as an indispensable key to the understanding of his later advancement. Mr. George says, "Whether man was or was not gradually developed from an animal, it is not necessary to inquire." That depends entirely upon the thoroughness of the inquiry it is proposed to make. Is it so obvious that the progress of man has nothing to do with the development of man? Surely knowledge is preferable to ignorance in regard to man's early history, as well as most other things. It is not all the same, for the purposes of truth, what theory we adopt of man's mode of origin. If the universe was jerked into existence out of nothing and altogether, some six thousand years ago, and if the first man came along with it perfected in intelligence, and endowed with a language suitable for the purposes of a comprehensive zoölogical nomenclature, then, indeed, all inquiry respecting the emergence of man is unnecessary. But this childish theory of his first appearance was long since exploded, and the growth of modern knowledge compels the adoption of another. Mr. George says, "We know that there have been geological conditions under which human life was impossible on this earth"; and he here tacitly gives away his whole case, for the implication is of a great historic order in nature, of the antiquity of the earth, and of the course of life as a time-problem of vast import. The indubitable records of life go back millions of years, perhaps millions of ages, in terrestrial history. And this life not only had its progress, but its incontestable mental progress. There was a slow and gradual passage from the lower to the higher, with successive epochs of advancing intelligence, the creatures nearest to man in organization coming last before man himself appeared.

We have here the conception of progress deep in the constitution of Nature. We have her method, which is that of progress by the operation of natural law. There was a time when the human race did not exist upon the earth, although it had been for countless ages a theatre of developing life. Will Mr. George maintain that man did not come in conformity with the preëxisting order? Does he deny that man is a part of Nature, the sequel of an organic series, and to be studied and interpreted in the light of the great unfolding law of this series? All the facts show not only that man has had a much greater antiquity upon this earth than was formerly supposed, but that he had a very low beginning. There was a prehistoric and primitive man, who dwelt in caves, made and used implements of stone, lived by hunting, and was the lowest kind of a savage. So much is established, whatever be the worth of speculations regarding his derivation from an

inferior animal. The civilized man of to-day is the descendant of this ancient and semi-brutal savage; and the problem of human progress involves an elucidation of the laws by which human nature has been developed and transformed, so that the creature that could not count his fingers may yet count a Newton among his descendants.

It is obvious that Mr. George's theory of progress can not in the least explain the earlier stages of social development. The cave-men did not say "Go to, let us progress," but they blindly struggled with their circumstances, and out of these struggles came improvement. Their experience was of conflict with wild beasts, which they had to kill in self-defense and to get the means of subsistence. For this purpose, the brutal and aggressive passions required to be strong. The life was predatory, and the aboriginal savage was cruel, revengeful, and delighted in the infliction of pain. How could such a creature, with his unsympathetic and unsocial nature, be brought into even the rudest forms of society? Only by a coercion so stern that it could subjugate his refractory passions, and force him into some kind of coöperation.

Mr. George is unable to see how war and slavery could ever have aided improvement, progress, and freedom. He quotes as absurd the reasons given for this view, namely, Comte's idea that "the institution of slavery destroyed cannibalism," and that "slavery began civilization by giving slave-owners leisure for improvement." But these are by no means the reasons on which this view rests. The question is, how brutal men were first subjugated and learned the lessons of subordination, which are the first steps of social progress. A coarse and inexorable discipline was required, such as befitted the natures to be subdued. War and slavery were just those relentless agencies that could force savages to work together, and habituate them to that respect for power which was an indispensable condition of the lowest forms of social order. The strongest man became the chief and the despot. Tyranny was indispensable. Where the moral condition of men was evinced by the habitual practice of cruelty, the wanton destruction of life, the torture of prisoners, cannibalism, and human sacrifices, the restraining power had to be inexorable and ferocious. It was by the arbitrary discipline of war that men first learned obedience; and, as the chief became king and government a military despotism, there gradually grew a stability in social relations and a progress of social institutions. War was an education in obedience, but not the sole education. Slavery was the result of war. Prisoners not killed were reduced to bondage. Despotic coercion was thus systematized, and the benefits of war were thus gained in time of peace. With his unsubdued nature, the habit of submission and of continuous application could only be acquired by the aboriginal man through a long apprenticeship of painful enslavement.

Recoil as we may at these contemplations, there is no evading the fact that this is Nature's method of human progress, and accordingly as we value the result must we appreciate the means that brought it about. That war may now hinder the beneficent work which it formerly promoted, is undeniable; but we are not to forget the part it has played when we undertake to explain the conditions and causes of human progress. What is all history but a bloody record of War's and Slavery's violence and injustice? Men are greatly changed and greatly improved, but civilization is still barbarian. Hostility looking to war is the international norm. We have plenty of survivals from our savage ancestors. Animals that they hunted from necessity, we hunt for sport; the gratification of killing continues. War is a regnant profession, the pastime of Christendom;

and slavery disappeared from among us but yesterday. And how did it go? As a behest of the humanity of the nation? As a victory of philanthropy, education, Christianity, and the higher forces of progress? No! it was not removed by the national volition, but it went out in a convulsion of domestic carnage.

Obviously there is a great deal to be done yet before man will be prepared to take the work of human progress out of the hands of Nature, and carry it on in his own wiser way. He can do much; but the first thing he has to learn is that he can not do everything, and to find out what is practicable of accomplishment. He can not realize his dreams, and can only embody a small part of his aspirations. By his pre-scientific and unscientific education, he is not imbued with the method of Nature, and is too unconscious of the difficulties and impediments in the way of attaining his sanguine hopes. Dwelling, in virtue of his predominant culture, in an ideal world that he constructs to suit himself; taught by novelists, dramatists, and poets, whose function it is to create imaginary worlds; familiar with religious doctrines which teach the facile convertibility of human nature; studying history which is ever occupied with human doings, and ever exaggerates the offices of great men; and surrounded by a world filled with suffering and injustice—men come to think that all this evil might be quickly done away with if there were only the disposition and the will. As Mr. Bagehot somewhere says, only a short time ago it was the common belief that, if everybody would set to work in good earnest, human society might be renovated and perfected and brought to a millennial condition in about ten years. Science, as it confers a deeper knowledge of the order of the world, sobers our judgment and dissipates these pleasing illusions. Let it not be said that science thus becomes obstructive, and paralyzes exertion; on the contrary, it is promotive of real progress by checking futile effort, and disclosing the conditions and the way by which exertion may be made most effectual and substantial conquests achieved. And, in these times that are so prolific of social Utopias, no teaching is more valuable or more wholesome.

MONDAY-LECTURESHIP PHILOSOPHY.

In the absence of Rev. Joseph Cook, the work of the Boston Monday lectureship has gone on by the aid of other clerical talent. The course was opened December 6th by Bishop Clark, of Rhode Island, who gave an address on "The Seen and the Unseen," of which an authentic version was published in the "Boston Traveler."

The Bishop succeeded well in adapting himself to the new circumstances. He entered easily into the general line of speculation for which this lectureship has become renowned, and filled the shoes of its Rev. Founder to a nicety. Whether it was the effect of association, or blue-Monday, or what, the speaker glided into the peculiar habits of the place, and indulged in logical licenses which could have been no novelties to his auditors. The Bishop discussed the problems of matter and spirit, the connection between the body and the soul, and the problem of personal immortality; and he here opened the question of the relation of religion and science in so explicit a way that readers on our side can not fail to be interested.

After an elaborate preliminary argument, he says: "The bearing of all this upon the question of our own personal immortality gives to the subject a most profound and solemn interest. It is hardly conceivable that man should have been endowed with immortality, and yet so constituted as to be unable to arrive at any satisfactory proof of the fact. To those who receive the records of the

New Testament as authentic and true, no further demonstration is needed." And yet a little further on this important position is very materially qualified. The Bishop points out that the Scriptural presentation of the doctrine of immortality is neither made prominent nor emphatic, and, notwithstanding "its profound and solemn interest," he gives reasons why it was best to leave it meager and obscure. He uses the following language: "The light that is thrown upon the next stage of existence in the Scriptures is designedly somewhat general and limited. All the direct information on the subject which they give could be condensed into a very small space. The eschatology of the Old Testament could all be written on a single page, and very much in the New Testament which has been supposed to relate to the subject is now referred to the setting up of the kingdom of truth and righteousness here on earth. 'The kingdom to come' in many cases means simply the kingdom of Christ among men. Revelation was not intended to gratify our curiosity, and it would not be well to make the veil which hangs between us and the future too translucent. Our work is here, and, if that work is properly done, we can afford to wait until an actual entrance into the next world reveals its mysteries. The time is not most properly employed which is spent in speculating about these mysteries."

This is rational and encouraging, and a wide departure from the traditions; for theology has always maintained that the universe is insufficient for man, even during the short time that he occupies it; and that the knowledge of his immortal future is a thousandfold more momentous to man than all he can learn about the present world. In liberal contrast to this, the Bishop now assures us that the teachings of revelation upon this subject are general and limited; that it was not intended merely to gratify our curiosity; that it would not be well to remove the veil that hides the distant future; that our work is here; that we can afford to wait; and that speculation about those mysteries is not the most profitable.

But, having indulged in this little episode of common sense, the Bishop seems to have remembered where he was, and quickly tacked back into the middle current of the Monday lectureship. There is no more talk of unprofitable speculations, and veils not to be rent. The secret of this transcendental mystery of spiritual existence *must* be plucked out, and it must agree with the calculations about it, or life is a cheat and all nature an empty mockery! This view is enforced with rhetorical emphasis in the following spirited passage:

"A division as old as Aristotle separates speculators into two great classes—those who study the How of the universe, and those who study the Why. All men of science are embraced in the former of these, all men of religion in the latter." I would like to understand both, if this is possible; but, if I must choose between the two, I would rather know the reason for which I exist than the mode by which I exist. The one is an end, the other only a means. If it is impossible to discover the end, or if that end, when it is supposed to be discovered, does not seem to be such as justifies the elaborate process by which it is reached; if all the magnificent discoveries of science land us in the conclusion that the universe is only a great clock put together and weighted and wound up to run for a certain period, and then when it has struck the last hour to fall to pieces and become resolved into the materials of which it was originally made—the clock having marked the process of time faithfully and truly as long as the flow of events continued, but the time itself leaving behind no permanent results which abide after the clock has ceased to strike—if the end of existence is exhausted in the process by which that existence is registered, and terminates with the process; or, again, if the universe is only a huge electric wheel throwing out sparks of life which glisten for an instant in the darkness and vanish for ever; or, again, if man is only the effervescence of a physical compound that buds and blossoms and then dies as soon as the soil furnishes no further sustenance—

why, then the universe is a sham and man an impertinence. All comes to nothing in the end, consciousness ceases when the phosphorus in the brain ceases to burn, and with the end of consciousness the material world might as well shrivel and die and come to nothing also.

This is a significant enunciation, and will bear pondering. We have seen no clearer statement of the respective attitudes of the theological mind and of the scientific mind toward the things of this world. What is the value of the great scheme we call nature taken at what we know of it? Margaret Fuller, neither theologian nor scientist, but fond of the mystical, offered, on the whole, to "accept" this universe. Bishop Clark, not to be taken in by shams, will accept it conditionally, that is, if he has assurance that its end is such as to justify the process by which it is reached. The universe has no worth in itself, and can only acquire it as it is found to conform to the theological standard—a standard, moreover, which was set up in ages of ignorance before anything had been found out concerning the nature, character, method, or magnitude of the object valued. Here the universe is, a mighty, boundless, unfathomed fact; if it squares with the theological ideal of what ought to be its design—an ideal framed without any knowledge of its constitution—it may be approved; otherwise, it is a humbug, and, the sooner it shrivels into nothingness, the better.

It is to be here noted that on either theological alternative science is suffocated. Theologians claim to have long known the grand why and wherefore of this universe, but that never inspired them to inquire into its how—never led to science. For, having the greater explanation already, why should they concern themselves about lesser explanations? The greater explanation not only superseded the lesser, but condemned them. Familiar with the futurities, and having in hand the lever that controls the beatitudes and the torments of an immortal destiny, it would have been recreancy for the theologians to favor trivial inquiries into what was doomed soon to "pass away as a scroll." They were logically bound to resist all tendencies to such trifling in this probationary world. So, the men who knew the why proscribed, imprisoned, strangled, and roasted the men of vain curiosity who strove to understand the frivolous how. There was, therefore, plenty of consistency in the orthodox antagonism to the spread of the spirit of science.

But if, on the other hand, the why can not be known as the theologians claim to know it, independent of all knowledge of the how, then on the authority of Bishop Clark the universe is a sham, and who is going to get up much interest in the study of shams? A man will not seriously inquire into that for which he has no respect; and, just to the degree in which people are imbued with this spirit of contemptuous indifference for the present world, will be their carelessness in relation to that scientific truth which raises the value of life in proportion as it is known and applied.

And which is the most reverent and the most truly religious attitude—not to raise any question of humility—that which assumes to pronounce on the aims and purposes of the universe, while contentedly ignorant of all truth regarding its order, or that which searches out its wonderful constitution, that it may rise to its plans and purposes, as gathered from its beautiful structures, its exquisite harmonies, its beneficent adaptations, and the solemn grandeur of its mighty movements? We protest against the doctrines which the Bishop offers us in the name of religion, as well as much else that emanates from the platform where he spoke. And we would respectfully suggest to the devotees of the Monday lectureship, if it would not have been

better to avail themselves of the absence of St. Joseph to get a few lessons in religious liberality by holding "deacon meetin's" and listening to the reading of "Scotch Sermons."

LITERARY NOTICES.

SCOTCH SERMONS, 1880. New York: D. Appleton & Co. Pp. 345. Price, $1.25.

THIS book is a surprise, and as gratifying as it is unexpected. Its title is anything but inviting. Of all branches of literature sermons are generally and justly pronounced the dullest, and of the class of sermons, everybody would expect to find the Scotch the driest. This is what sharpened surprise and produced actual astonishment when we looked into this unpromising volume. We have been accustomed to regard Scotch Presbyterianism as the narrowest and most intolerant and intractable form of Calvinistic orthodoxy, which would be the very last to yield to the liberalizing tendencies of the time, but we have been much mistaken. The mechanical law that action and reaction are equal and opposite seems to hold rigorously in the theological sphere, so that the counter-impulse now displayed in the Scottish Church is, perhaps, more vigorous, comprehensive, and fruitful than is to be found in any other religious body.

This volume, dedicated to Dean Stanley, consists of twenty-three sermons, preached by various men, located in various places, and all clergymen of the Church of Scotland. Its editorship is anonymous, but its editor declares that it "has originated in the wish to gather together a few specimens of a style of teaching which increasingly prevails among the clergy of the Scottish Church. It does not claim to represent either the full extent of that teaching or the range of subjects on which, in their public ministrations, its authors are in the habit of discoursing. It may, however, serve to indicate a growing tendency and to show the direction in which thought is moving. It is the work of those whose hope for the future lies not in alterations of ecclesiastical organization, but in a profounder apprehension of the essential ideas of Christianity; and especially in the growth within the Church of such a method of presenting them as shall show that they are equally adapted to the needs of humanity and in harmony with the results of critical and scientific research."

There is, of course, considerable inequality in these productions, coming as they do from such diverse sources, but they are all of a superior character, and there are a unity and a harmony in the views advanced which show that the liberalizing movement in the Scottish Church is broad, consistent, well defined, and well matured. The writers treat their respective topics independently, but with a remarkable concurrence of opinion, which shows that the more expanded views are the result less of any effort at agreement than of an unconscious growth of rational conviction.

But these sermons are not less remarkable for their free and catholic spirit and advanced principles than for the intellectual power which various of them evince in dealing with the present phases of religious thought. They are not the mere impatient protests of men chafing under the influence of an outworn system, but they are philosophical in temper, constructive and conservative in tendency, and evince a masterly grasp of the questions that are now tasking the best minds of the age. There is no timidity, no panic about imperiled faiths, and the old errors are repudiated with decision, but without harshness or bitterness. It is ably shown how religion is the gainer by being freed from the false beliefs that have been so long associated with it, and so widely mistaken for it.

These sermons are, moreover, remarkably free from that jealous antagonism to Science which in these days characterizes so much of our mediocre literature of theology. Science is neither fiercely denounced as leading to materialism, nor coldly complimented and left to go her ways. Her results are cordially accepted as a great revelation of truth, and of truth which is also of the highest religious importance. Instead of shrinking with horror at the scientific doctrine of development as something which threatens to sweep away all religion, these clear-sighted men recognize that this doctrine is at the basis of religion itself.

They understand that all stereotyped faiths and fixed creeds are doomed to be left behind, while the spirit that animated them must assume new forms under a widened and advancing religious experience. It is certainly a most remarkable result that out of the Scottish Church, in 1880, should come this weighty proclamation to the religious world, that the great law of continuity and evolution, as unfolded and established by modern science, is to become a foundation and bulwark of religious faith in the future. "He that hath ears to hear, let him hear."

We should be glad to reprint half these sermons in the "Monthly," but, as this is impossible, we give a few passages illustrative of the standpoint of the book. The Very Rev. John Caird, Principal of the University of Glasgow, has the first discourse, on "Corporate Immortality," which is an able plea for interest in "The things of this life" as opposed to the overshadowing claims of another world. He says:

It needs little reflection to perceive that the whole order of things in which we live is constructed not on the principle that we are sent into this world merely to prepare for another, or that the paramount aim and effort of every man should be to make ready for death and an unknown existence beyond the grave. On the contrary, in our own nature and in the system of things to which we belong, everything seems to be devised on the principle that our interest in the world and human affairs is not to terminate at death. It is not, as false moralists would have us believe, a mere illusion, a proof only of the folly and vanity of man that we do not and can not feel and act as if we were to have no concern with this world the moment we quit it. It is not a mere irrational impulse that moves us, when, in the acquisition of knowledge, in the labors of the statesman and legislator, in the houses we build, the trees we plant, the books we write, the works of art we create, the schemes of social amelioration we devise, the educational institutions we organize and improve, we act otherwise than we should do if our interest in all earthly affairs were in a few brief years to come to an end. It is not due to a universal mistake that we work for a thousand ends, the accomplishment of which we shall not live to see; that the passions we feel are more intense, the efforts we put forth immeasurably greater, than if we were soon and for ever to have done with it all. Even the desire of posthumous fame, which has been the theme of a thousand sarcasms and satirical moralizings, the passion that impels us to do deeds and create works which men will be thinking of and honoring when we are gone, does not rest on a mere trick of false association, which your clever psychologist can explain so deftly, but is the silent, ineradicable testimony of our nature to the share we have in the undying life of humanity.

Does any one press on me the thought that, say what you will of the future, death to each of us is near, and no ulterior hope can quell the nearer anxiety as to what is to become of us, and how we are to prepare for that fast-approaching, inevitable hour? Then, I answer finally that, to whatever world death introduce you, the best conceivable preparation for it is to labor for the highest good of the world in which you live. Be the change which death brings what it may, he who has spent his life in trying to make this world better can never be unprepared for another. If heaven is for the pure and holy, if that which makes men good is that which best qualifies for heaven, what better discipline in goodness can we conceive for a human spirit, what more calculated to elicit and develop its highest affections and energies, than to live and labor for our brother's welfare? To find our deepest joy, not in the delights of sense, nor in the gratification of personal ambition, nor even in the serene pursuits of culture and science, nay, not even in seeking the safety of our own souls, but in striving for the highest good of those who are dear to our Father in heaven, and the moral and spiritual redemption of that world for which the Son of God lived and died—say, can a nobler school of goodness be discovered than this? Where shall love and sympathy and beneficence find ampler training, or patience, courage, dauntless devotion, nobler opportunities of exercise than in the war with evil?

The Rev. Dr. Ferguson, of Strathblane, has a powerful discourse on "Law and Miracle," in which he says:

Christianity, then, is no rigid system of dogma, or of ecclesiastical forms elaborated long ago and incapable of growth or change. It is rather a living organism, drawing nourishment to itself from every side, and affected by the life-pulsations of every age. Look, for instance, what a vast difference between Christianity in the first and in the nineteenth century! Then it was struggling for existence between Judaism on the one hand and paganism on the other; now it has conquered its position, and extorts recognition at least from its bitterest opponents. It has revolutionized the whole structure of society, and formed manners and customs and habits of thought.

Of the effects produced by this habit of sifting and winnowing which goes on in history, we have a good example in the doctrine of miracle. In our own day that doctrine does not occupy the prominent position it formerly had. It has fallen into the background, and lost its apologetic value; but, at the same time, its actual relations to the circle of Christian truth have been made clear. In the course of last century, on the contrary, the sharpest attacks which Christianity had to sustain were directed against

this side. The contest raged round the credibility or incredibility of miracle, as if the whole of revelation depended upon the issue. In reality, however, no vital point of revelation was endangered. It was an affair of outposts altogether, and the work so energetically assaulted and defended had little importance for the citadel in the rear. Neither the philosopher who argued against nor the divine who contended for miracle was dealing with the essence of Christianity, and the complete triumph of either would have made little change. At the worst, a dogma of the Church would have been overthrown; but the dogmas of the Church and the religion of Christ are not synonymous terms.

In enumerating the various causes which have produced a new "climate of opinion" in relation to miracles, Dr. Ferguson says:

First of all, there is the scientific conception of the universality of law. This may truly be said to be the revelation of our own age, not in the sense that it was unknown to our predecessors, but that in the present day the conception has been so extended and generalized as to dwarf its former proportions. It has passed out of the laboratory of science into the common possession of men, and is now one of the great truths so firmly established that they become truisms. We never stop to reason about them, and, were any one rash enough to call them in question, we should not give him even a patient hearing. Moreover, the idea of law is not to be confined to the material world, with its indestructible treasury of force. It must be carried over into the world of mind, and be seen at work there also, not indeed with the rigidity of physical law, but within the large limits which freedom of thought and action demands. It is to be traced in the advance of civilization, in the development of history, in the growth of religion, in relations such as those between morals and art, between society and government, between national life and literature. Now, it is not difficult to see how such a conception must indispose men under its influence to look favorably upon miracle. In the idea of order everywhere supreme, calm, eternal, there is a sublimity which fills their imagination and stimulates their intellect. Any interruption of its uniform course, any breach of continuity, would be a blemish in the picture, and not an additional charm—would be, indeed, a positive pain to thought, and, instead of disposing the mind to reverence, would fill it with confusion and doubt.

The Rev. Professor Knight, of St. Andrews, has a sermon of great interest and moment on "The Continuity and Development of Religion," in which he says:

It does not, therefore, follow that, if we can explain the origin of a particular belief by tracing its parentage, and finding that it has sprung from inferior elements, the validity of the belief itself is in the slightest degree imperiled. Nay, it is indisputable that, if the human mind has grown at all, its religious convictions—like everything else belonging to it—must have changed. Our remote ancestors could not possibly have had the same religion as ourselves, any more than they could have had the same physiognomy, the same social customs, or the same language. Thus, the intuitions of subsequent ages must necessarily have become keener and clearer, at once more rational and more spiritual, than the instincts of primeval days; the clearness, the intelligence, and the spirituality being due to a vast number of conspiring causes. And, if the opinions and the practices of the race thus change, the change is due to no accident or caprice, but to the ordinary processes of natural law. It can not be otherwise; because, since no human belief springs up miraculously, none can be maintained in the form in which it arises for any length of time. Thus, the "increasing purpose" of the ages must inevitably bring to the front fresh modifications of belief. If our theologies have all grown out of something very different, why should we fear their continued growth? Why should any rational theist dread the future expansion of theistic belief? If it has grown, it must continue to grow, and many of its existing phases must disappear. The controversies of our time are the phases of its evolution. But is it now so very perfect that we would wish it to remain stationary at its present point of development? That its present phases should be permanent? May we not rather rejoice that "these all shall wax old as a garment," and that, "as a vesture, they shall be changed"; while the Object—of which they are the interpretation, or which they try to represent—endures, and of its immortality there shall be no end? It may even be affirmed that one of the best features in every human belief is its elasticity; that one sign of its vitality is its amenability to change. Were it irrevocably fixed, it would have some secret affinity with death and the grave. Paradoxical, therefore, as it may seem, if religion be among the things that can not be shaken, it must change. Its forms must die that its spirit may live; and the condition of the permanence of the latter is the perpetual vicissitude of the former. Curious it is that some of its most ardent advocates can not recognize it under a new dress, that even its disciples misconstrue it when it changes its raiment. They think it a foe if it is differently appareled. But how often in all human controversy the combatants are merely speaking different dialects while they mean the same thing! But, granting that the opinion of the world is an organic whole, that all human conviction—with its present variety and complexity—has grown out of very lowly roots, and that our most sacred beliefs have emerged from others that are different, a further and a far more important question lies behind this admission. It is this: How are we to interpret the whole series from beginning to end? It is not enough to say that there has been progress; what meaning are we to attach to the term progress? Are we to think of it as simple succession and accumulation, the mere addition of new links to a chain of devel-

opment? We know that men "rise on stepping-stones of their dead selves to higher things," and that the "individual withers, while the race is more and more"; but do the individuals and their beliefs only resemble beads which have been strung on a thread of endlessly developing succession? What has the race been *doing* during all this onward process of development? And has it at every stage been the victim of continuous illusion? Or has it all the while been in the closest contact with Reality, a reality which it partially understands, and interprets to good purpose? In other words, is the history of religious ideas merely the record of attempts made by men to project their own image outward, to throw their thought around an impalpable object which it has never yet been able to grasp? Or is it the story of successive efforts, more and more successful, to explain a reality which transcends it, but to which it stands in a definite and ascertainable relation? Do the gropings of experience in the matters of religion record a long and weary search, with no discovery rewarding it? Or are they the efforts of human apprehension to realize the divine, to get at the "last clear elements of things," with disclosure at every stage, and a steady approach to the goal which is continually sought and approximately reached? I think it is past controversy that if the religious education of the human race has been a purely subjective process, if it has been merely an upward tendency of aspiration, it is now no nearer its goal than ever it was. If we can only approach the Infinite by the journeyings of finite thought or through sighs and cries of aspiration, the journey that way is endless, and the end is nowhere visible. But may we not find the object everywhere? May not the discovery have been as continuous as the search, and the two be simultaneous now? I think that we may affirm that the human race has lived in the light of a never-ceasing apocalypse, growing clearer through the ages, but never absent from the world since the first age began.

MODERN THINKERS: Principally upon Social Science. What they Think, and why. By VAN BUREN DENSLOW, LL. D. With an Introduction by ROBERT G. INGERSOLL. With Eight Portraits. Chicago: Belford, Clark & Co. Pp. 384.

THIS volume consists of a series of brief personal sketches of several of the leading thinkers of modern times, together with critical disquisitions on their labors, influence, and character. The thinkers selected for study are all of the aggressive or revolutionary type, and they were chosen furthermore because of the more or less intimate bearing of their advanced ideas on the subject of social science. Three Englishmen, Adam Smith, Jeremy Bentham, and Herbert Spencer; two Frenchmen, August Comte and Charles Fourier; a Swede, Emanuel Swedenborg; a German, Ernst Haeckel; and an American, Thomas Paine —are the characters selected for examination.

The author has a brief preface explaining the origin of his book, and offering some preliminary suggestions regarding its method and purpose. The essays were written for the "Chicago Times," and at the suggestion of its editor they were first published in that newspaper. The intelligent interest elicited by them has induced the author to bring them out in this more permanent form. It was an excellent idea, and does credit to the editorial sagacity and liberality of Mr. Storey. People are undoubtedly more and more confining themselves to the reading furnished by newspapers, and we see no reason why, under the pretext that their business is the promulgation of news, the daily press should confine itself exclusively to the scattering of information on ephemeral and frivolous subjects.

Colonel Robert J. Ingersoll contributes a spicy introduction to the volume, briefly presenting his views of the various characters it deals with, and pointedly reillustrating his well-known anti-theological position. In this, however, he is in entire harmony with the spirit of the volume, which is characterized throughout by hostility to everything theological, and abounds in unsparing invectives against the Church, the priesthood, and the Christian gospel. The work is written in a free, vivacious, and somewhat dashing style, and is eminently readable. The mode of treating the subjects is independent, sensational, and bold. Much of its exposition is instructive, evincing good preparation; and much of it will be unsatisfactory to those who prize deliberate and unprejudiced work. As a piece of manufacture, the volume itself is no credit to Chicago.

The essay that has most interested us is on the American subject, Thomas Paine, whom the author regards as the "representative critic, destroyer, and revolutionist of his period.... He was gifted, as no man ever was before or since, with the fatal and unhappy faculty of suppressing the good and

exaggerating the ill in the men upon whose conduct he was called to comment, and in the institutions he aimed to overturn." Dr. Denslow makes out a specious case for Paine as the author of the "Letters of Junius"; but Mr. Ingersoll interposes to protect the great freethinker against this scandalous imputation, and protests that Paine "was neither a coward, a calumniator, nor a sneak," and he gives a few reasons that are weighty against the hypothesis that Paine was the author of these celebrated letters.

Dr. Denslow maintains, with more show of reason, that he wrote the "Declaration of Independence," and Mr. Ingersoll is inclined to think that this claim is well founded. Decisive reasons are given why Jefferson could not have been its author, and there is much forcible evidence that Paine was the only man who could have done it. The following passages will afford a good illustration of our author's manner of dealing with his topics, and also sum up his estimate of Mr. Paine:

But, enough! The Declaration of Independence must hereafter be construed as a fabric whose warp and woof were Thomas Paine's. It was admirably adapted, as a revolutionary *pronunciamiento*, to fire the colonial heart to a war for separation which, though placed on utterly inadequate and untenable grounds by that Declaration, yet had good grounds which are not mentioned in it. Those were, simply, that not having any of the materials for an aristocracy in this country, we could not coalesce into one government with Great Britain, whose government was aristocratic. If we had been permitted to elect members to her House of Commons, what should we have sent to her House of Lords? The alleged grievance of taxation to reimburse the British Treasury for expenses incurred in our defense was in no sense a money grievance. The money having been expended for our benefit, it was our duty to pay it. There could surely be no duty resting on Londoners or Yorkshiremen to pay the expenses of Montgomery's march to Quebec or Braddock's to Pittsburgh. The real difficulty was, that we needed a sovereign government, and could not be admitted into the British one, because that was aristocratic and we had no aristocracy. This was not a grievance, but it was a good cause for national separation. The Declaration, like many popular documents, substituted sentiment for sense, passion for wisdom, fiction and rhetoric for history and fact, concealed the double merits of the case and helped on the war, in the same way that the stupidity of George III did.

We may now fairly estimate Thomas Paine in his two most marked characters, as a master of rhetorical invective and as a revolutionist; for, after attributing to him the authorship both of "Junius" and of the Declaration of Independence, as well as "Common Sense," "The Crisis," and "The Rights of Man," he still subsides into the category of brilliant sensational agitators endowed with a considerable force of prophetic insight, who fell far short of the qualifications essential to a statesman, or even of the appreciation of what statesmanship is. There can be no statesmanship without cool-headed candor, judicial calmness, capacity for guarded, just, and moderate statement, which will bear the test of time, perfect fairness toward adversaries, gratitude toward supporters, and a capacity for harmonizing adverse or conflicting elements by practicing, in non-essentials, unity, and in essentials, charity. Webster, Clay, Calhoun, Hamilton, Madison, Washington, and Franklin possessed these qualities, but Paine, the scathing and withering accuser, lacked them all. If it be a galling and unbearable tyranny for a conscientious man, with a tongue that has an infinite capacity for accusation, and none for pardon, to go about, like a section of the day of judgment, applying to every one who stands in his way such exacting and ideal tests and standards of virtue that human nature, which seems very tolerable to those who are looking at it without the blasting motive, is foredoomed by it to certain damnation and infamy, then Paine was a species of moral tyrant, always demanding the impossible of others. Notwithstanding his profession and belief that he was an apostle of freedom, Paine's fundamental belief in politics was that the government was always wrong, that it was inherently an evil; that the less there was of it the better, but that, however reduced in dimensions, whatever should be left of it would still be bad by reason of its being government. It was as wrong when vested in Washington as in George III, and he had good reason to know that it was as wrong when wielded by Robespierre as when presided over by Louis XVI. On the contrary, Paine imagined that the aggregated ignorance and incapacity of all the vast unskilled millions who had been pushed out of the work of government by the superior force and cunning of those in power were the actual repository of political wisdom and purity. The iceberg needed only turning over. He began with the creed, which he retained to his death, that government was not an affair of skill, but merely of honesty; not a problem of difficulty, but merely of good intentions. Holding these views, it followed that if it could in some way be got out of the hands of the skilled and interested few who were educated to it, and had made a profit out of it, into the hands of the unskilled and disinterested masses, who were not educated to it, and who, he assumed, would not seek to make a profit out of it, then good government would be perfectly secured. The inverted iceberg would bloom into an enchanted island, melodious with the songs of birds and mellifluous with the scent of flowers. It did not occur to him that the hereditary principle in government might sup-

ply permanency, nationality, and non-partisanship to the executive, while an elected executive would always be the mere chief of a party and never the head of a nation; or that the bungling charlatanism of the unskilled democracy might result in misgovernment, waste, despotism, and passionate folly. So little did he comprehend both sides of the question, that, in "The Rights of Man," he predicted that within ten years the monarchical and aristocratic principles would have disappeared from all enlightened governments of Europe. The instant his supposed government of the people had got under way in America, Paine immediately saw in it an oligarchy in power, new in personality, but not materially different in meanness and avarice.

THE SCIENTIFIC BASIS OF SPIRITUALISM. By EPES SARGENT. Boston: Colby & Rich. Pp. 372. Price, $1.50.

THIS work, copyrighted in 1880, has but just appeared, but since its publication its versatile author has passed away. Mr. Sargent was born in 1812, studied in Harvard College, and early became an editor in Boston. He pursued this vocation awhile in New York, and then again resumed it in Boston. He edited various popular "Speakers," "Readers," and rhetorical books for the schools, and wrote many plays both comical and tragical. He also wrote "Life of Henry Clay," a volume of poems, an abolition book, and "Arctic Adventures." That he should have dipped into spiritualism was but natural with his love of diversified literary occupation; and so, a dozen years ago, he printed "Planchette, or the Despair of Science," and closed his career with the production of the volume now before us.

As was to be expected, the work is one of considerable literary merit, well digested, attractively written, and made lively by a pervading spirit of criticism. If we may be allowed the paradoxical suggestion, Mr. Sargent goes the "whole hog" in spiritualism. He believes it all, sticks at nothing, and slashes right and left at everybody who objects to it. He claims to be on the winning side, and says that in the last forty years spiritualism has gained twenty million adherents. One would think that with this he might "rest and be thankful," but it does not satisfy him. It seems that, among these twenty million believers, the scientific men generally are not to be found, and it is this fact which caused Mr. Sargent to write his book. He thinks the twenty million people of all sorts, who need not be further characterized, are right, and that the scientific men—the sole class whose business it is to search out the truths of nature—are wrong; and it is his object to show that spiritualism has just as much a valid scientific foundation as any of the recognized and established branches of science. We shall not undertake to answer his arguments, if such they may be called, but will only observe, as we have repeatedly done before in this connection, that the most fundamental of all distinctions is confused throughout the work. The supernatural, or that which by its very term is above and beyond nature, is mixed up and confounded with nature itself, and spiritualism is declared to be "a purely natural fact." Yet, if this doctrine had twenty times twenty million adherents, science could not accept it, because it takes for its object of investigation the natural as opposed to the supernatural. In so far as alleged "spiritualism" involves human phenomena, it is of course within the purview of science, and scientific men will be certain to take these phenomena up in their own way and in their own time. But they must be allowed to mark out their own work, and the problem as presented by the twenty million does not come in a shape suitable to be dealt with by rigorous scientific methods. The men of science begin by doubting, and cultivating this state of mind as a virtue; they continue to doubt until evidence extorts acquiescence, while assent even then goes no further than to things regarded as actually proved; the "twenty million," on the contrary, begin by believing, hold this state of mind to be a virtue, and go on believing without much perplexing themselves over questions of evidence. To them the phrase "the scientific basis of the super-scientific" would involve no contradiction.

PROGRESS AND POVERTY; an Inquiry into the Cause of Industrial Depressions and of Increase of Want with Increase of Wealth: The Remedy. By HENRY GEORGE. New York: D. Appleton & Co. Pp. 512. Cheap edition, with a new preface, in paper cover. Price, 75 cents.

WE are glad to announce the appearance of a cheap popular edition of this suggestive book, by which it will be made accessible

to many who could not have secured it in its previous form. We are happy to note, further, that it has proved a very considerable success. Four editions have been called for in this country; the Germans are printing a translation in parts; it is discussed in French and Italian periodicals; and an English edition is in preparation. The work is everywhere looked upon as an important contribution to political economy, and as an eloquent and vigorous discussion of imminent social problems. It is a wholesome sign of the growing liberality of the times that a work should be so cordially received and highly appreciated, while at the same time there is general and decisive dissent from its main conclusions. It is read and enjoyed for its humane spirit and the novelty and independence of its views; but we do not observe that Mr. George makes disciples who endorse his leading and distinctive doctrines. It is, however, admitted that he has contributed to the elucidation of political economy by his adverse criticism of prevailing opinions on that subject; and it is certainly no small merit to have done something for the advancement of this inquiry, and the clearing up of important economical questions.

MEDICAL HERESIES HISTORICALLY CONSIDERED. A Series of Critical Essays on the Origin and Evolution of Sectarian Medicine, embracing a Special Sketch and Review of Homœopathy, Past and Present. By GONSALVO C. SMYTHE, A. M., M. D., Professor of the Practice of Medicine, Central College of Physicians and Surgeons, Indianapolis. Philadelphia: Presley Blakiston. Pp. 228. Price, $1.25.

IT was not the author's object in this volume to write a history of medicine, but simply to sketch the rise and fall of the different schools, sects, or systems of medicine, from the earliest historical period down to some of the more prominent heresies of the present day. The author writes with brevity, and does not enter into the consideration of the contemporaneous systems of philosophy or theology with which medicine in former times has been strangely and inconsistently commingled. All topics are also avoided which are merely of interest to the medical antiquarian. The author says in his preface: "My second object is to furnish the regular profession with some much-needed information in regard to homœopathy. Few busy practitioners have the time or inclination to investigate the claims of this school, and, although they are brought in contact with it daily, know little or nothing of its real principles. I have presented the principles of this school fairly, quoting the exact words of its founders at the expense of some repetition, in order that I might not be accused of misrepresentation. The discussion of these principles has been conducted from a scientific standpoint, and without ridicule, thus showing of what homœopathy consisted originally; and by quotations from the current literature of the school, with discussions thereon, showing what it is now. It is confidently believed that the condensed information contained in this little book will not be altogether without interest to the profession."

PASSAGES FROM THE PROSE WRITINGS OF MATTHEW ARNOLD. New York: Macmillan & Co. Pp. 333. Price, $1.50.

NOT only will the admirers of Matthew Arnold be gratified by this varied collection of his best utterances, but many, who are not familiar with or do not possess his works, will be glad of a representative volume like this, in which they can get some acquaintance with the thought of the eminent modern apostle of the gospel of "sweetness and light." The selections are systematic, being arranged under the heads of—I. Literature; II. Politics and Society; and III. Philosophy and Religion; and they have been collected with good judgment, and will prove very suggestive and gratifying to all cultivated readers.

THE JOURNAL OF PHYSIOLOGY. Edited by MICHAEL FOSTER, M. D., F. R. S., of Trinity College, Cambridge. Assisted in England by Drs. Gamgee, Rutherford, and Burdon-Sanderson; and in the United States by Drs. Bowditch, Martin, and Wood. New York: Macmillan & Co. No. 1, Vol. III.

WE call renewed attention to this admirable periodical, the only one in English thoroughly devoted to original physiological research. The progress in the arts of physiological experimentation and the untiring assiduity of the laborers in this field are fruitful of important results which are

both of general interest as extensions of scientific knowledge and of special moment to all the well-qualified members of the medical profession. The publication deserves to be liberally sustained.

THE BEAUTIFUL AND THE SUBLIME. An Analysis of these Emotions, and a Determination of the Objectivity of Beauty. By JOHN STEINFORT KEDNEY. New York: G. P. Putnam's Sons. Pp. 214. Price, $1.25.

THIS is not a text-book on æsthetics, but an attempt to deal with the underlying philosophy of the subject. Physical science, metaphysics, and theology profess to be no more dealt with than is necessary for the author's logical purpose. His chief claims are on the psychologic and the ethic side, and there he thinks he has made additions to the treatment of the subject. He does not attempt to deal formally with art or art criticism, but holds that his views may be carried out in application to the several departments of architecture, sculpture, painting, music, literature, oratory, poetry, and histrionics. The author modestly says in his preface: "While my treatise is intended, primarily, as a contribution to the philosophy of the science, I have endeavored to cast it in such form and style as to interest all intelligent readers, who, if they are patient over some parts of the work, may find it, elsewhere, and on the whole, compensatory."

A NEW SCHOOL PHYSIOLOGY. By RICHARD J. DUNGLISON, A. M., M. D. 119 Engravings. Philadelphia: Porter & Coates. Pp. 314. Price, $1.50.

THIS school-book has several things to commend it: it is neatly printed, it is elegantly illustrated, it carries an eminent name on its title-page as author, and is, consequently, we have no doubt, trustworthy in its statements; if, therefore, the publishers can not make a good thing out of it, it will be their fault. The drawback of the book is, that its author seems to know only physiology, while some knowledge of the growing mind is necessary to make a good book of science for educational purposes. It is a question-and-answer book "of the old type," to be learned by memory by young people. As this class embraces pupils of all grades, the book is suited to no special grade, and will be equally used to begin with, to continue with, and to finish with. This will be again favorable to its sale, but unfits it for intelligent educational use.

DIPHTHERIA: ITS CAUSE, NATURE, AND TREATMENT. By ROLLIN R. GREGG, M. D. Pp. 137. Price, $1.50.

ON the title-page of this book is printed the following, which are probably fundamental propositions maintained in the volume: "Spherical Bacteria, or Micrococci of Diphtheria, shown to be only Molecular Granules of Fibrin. Rod-like Bacteria, Bacterian termo, shown to be Molecular Granules of Fibrin, united into Fibrils, or fine thread-like prolongations."

The book is one that it belongs to the medical profession to judge of.

PUBLICATIONS RECEIVED.

Cases treated by the Lister Method. Reported to the Portland Clinical Society by Frederick H. Gerrish, M. D. Portland, 1880. Pp. 15.

The Anarchist. Socialistic-Revolutionary Review. Edited and publishd by Dr. Nathan Ganz. Boston, January, 1881. Monthly. Pp. 24. 60 cents a year.

Vennor's Almanac and Weather Record for 1880-'81. New York: American News Company. Pp. 84. 25 cents.

Annals of the New York Academy of Sciences. Vol. I. Nos. 11, 12, March, and No. 13, April, 1880. New York: Published for the Academy.

The Constitution of the Tartrates of Antimony. By Professor F. W. Clarke and Helena Stallo. Reprint from "American Chemical Journal." Pp. 13.

Reports of the Iowa Weather Service for the Twelve Months of 1878, and January, February, March, and April, 1879. By Dr. Gustavus Hinrichs. Des Moines, 1880.

Dictionary of Music and Musicians. Edited by George Grove, D. C. L. Part XII, Palestrina to Plain Song. London and New York: Macmillan & Co. 1880. Issued in quarterly parts, at $1.

Report on the Culture of the Sugar-Beet and the Manufacture of Sugar therefrom in France and the United States. By William McMurtrie, Ph. D. Washington: Government Printing-Office. 1880. With Maps. Pp. 294.

A Treatise on the Injurious and Beneficial Insects found on the Orange-Trees of Florida. By William H. Ashmead. Jacksonville, Fla. 1880. Illustrated. Pp. 78.

The Food of Fishes. By S. A. Forbes. Reprint from Bulletin No. 3. Illustrated. State Laboratory of Natural History. Pp. 60.

On the Present Condition of Musical Pitch in Boston and Vicinity. By Charles R. Cross and William T. Miller. Reprint from the "American Journal of Otology," October, 1880. Pp. 16.

The Coming Revelation: Its Principles. St. Louis, 1878. Pp. 40.

The Abdominal Method of Singing and Breathing as a Cause of Female Weakness. By Clifton E. Wing, M. D. Boston. Pp. 8.

Abridgment of the Nautical Almanac for 1881. By Riggs & Brother, Philadelphia. Pp. 150. 25 cents.

The Geological and Natural History Survey of Minnesota. Eighth Annual Report, for 1879. By N. H. Winchell. Illustrated. St. Paul, 1880. Pp. 183.

Drainage for Health, or Easy Lessons in Sanitary Science. By Joseph Wilson, M. D. Philadelphia: Presley Blakiston. 1881. Pp. 68. $1.

Report of the United States Fish Commissioner for 1878. Washington: Government Printing-Office. 1880. Pp. 988.

Introduction to the Study of Indian Languages. With Words, Phrases, and Sentences to be collected. By J. W. Powell. Washington: Government Printing-Office. With Maps. 1880. Pp. 228.

James Smithson and his Bequest. By William J. Rhees. Washington: Published by the Smithsonian Institution. Illustrated. 1880. Pp. 159.

Sketches and Reminiscences of the Radical Club of Chestnut Street, Boston. Edited by Mrs. John T. Sargent. Boston: J. R. Osgood & Co. 1880. Pp. 418. $2.

The Logic of Christian Evidences. By G. Frederick Wright. Andover: Warren F. Draper. 1880. Pp. 312. $1.50.

Extracts from Chordal's Letter. American Machinists' Publishing Company. New York, 1880. Pp. 320. $1.50.

Elementary Projection Drawing. By S. Edward Warren, C. E. New York: John Wiley & Sons. Twenty-four Plates. 1880. Pp. 102. $1.50.

A Text-Book of Elementary Mechanics. By Edward S. Dana. New York: John Wiley & Sons. 1881. Pp. 291. $1.50.

The Young Folks' Cyclopædia of Persons and Places. Illustrated. By John D. Champlin, Jr. New York: Henry Holt & Co. 1881. Pp. 936. $3.50.

POPULAR MISCELLANY.

The Age of the Trenton Gravels.—The age of the gravel in which flint implements have been found at Trenton, New Jersey, is carefully discussed by Mr. Henry Carvill Lewis, in a paper read by him before the Academy of Natural Sciences of Philadelphia. Mr. Lewis divides the surface formations of southeastern Pennsylvania into five clays and four gravels, of which nine deposits the Trenton gravel, as he calls the implement-bearing formation, is, except the recent alluvium, the most recent. At Philadelphia it is called the river-gravel and sand, and contains pebbles which are made exclusively from the rocks forming the upper valley of the Delaware River, and which have the flat shape characteristic of all true river-gravels. It is confined to the immediate vicinity of the river, and has been traced as far up as the Water-Gap. Throughout its whole course it lies within a channel previously excavated through the bowlder-bearing Philadelphia brick-clay and its red gravel, which have been shown to belong to the Champlain epoch. It is therefore later than those formations. The deposit is spread out to its greatest extent at Trenton, where the long, narrow valley of the Delaware, with its precipitous banks and continuous downward slope, opens out into the wide, alluvial plain at a lower level. The fluviatile character of this gravel is shown by evidence of various characters, as by the exposures of the "flow-and-plunge structure," in which the layers are seen to dip up-stream, as would be expected to result from the action of downward-flowing water, while the tertiary gravels show in their layers, dipping southeast, evidence of their deposition by incoming oceanic tides. It frequently, also, instead of lying in a flat plain, forms banks with a higher ground close to the present river-channel, and sloping down toward the ancient bank, as often takes place according to the laws of river deposits. The formation can not, however, have been made under the operation of any such flood as has been known within the historical epoch, for no such flood has supplied the amount of water which would be required. It also bears marks of ice-action. It may then be ascribed to a glacier; not to the great glacier of the glacial period, for that glacier at its melting deposited the much older brick-clay and red gravel, but to another more recent glacier whose flood flowed through a channel excavated in the deposits of the first glacial period. This second glacier was much smaller than the first, had its southern extremity confined to the valley, and probably corresponded with the age which European geologists style the *Reindeer period*. From the fact that the palæoliths found here are similar to the stone implements found among the Esquimaux, Mr. Lewis thinks that they may be the relics of an Esquimau race who once lived in the valley, and he suggests the *Esquimau period* as a suitable name for their age. Finally, he sums up his conclusions as follows: "1. That the Trenton gravel, the only gravel in which implements occur, is a true river deposit of post-glacial age, and

the most recent of all the gravels of the Delaware Valley. 2. That the palæoliths found in it really belong to and are a part of the gravel, and that they indicate the existence of man in a rude state at a time when the flooded river flowed on top of this gravel. 3. That the data do not necessarily prove, geologically considered, an extreme antiquity of man in Eastern America."

Prehistoric Mining in North Carolina.—Mining for mica has become a profitable pursuit in North Carolina. It is a curious fact that the best mines are located upon sites which afford evidence of having been worked in prehistoric times, and are called there "old diggings." Most of the old works probably belonged to the mound-builders, but a tradition coming down from the Indians ascribes some of them to white men. The tradition has recently been confirmed by the discovery of old implements of iron in a prehistoric shaft in Macon County, which are fully described and figured by Mr. F. W. Simonds, in the "American Naturalist." The implements were found in the rubbish which had accumulated within the shaft, between thirty-five and fifty feet below the surface, and consist of an axe of a pattern now rarely met with, light in weight, and having on the blade a brand which has been nearly effaced by erosion; two articles which were evidently gudgeons of a windlass, with heads pronged for the insertion of levers, pointed at the ends, so that they could be driven into a wooden roller, and having the lower part of the shank squared to prevent their turning in the wood, and the upper part round so as to serve as an axle for the roller; and a wedge with battered head. All were of wrought iron, and had probably been worn out and thrown away. Mr. Simonds suggests that they are the relics of a party of Spaniards who left one of the ancient colonies or expeditions on a "prospecting tour" and tried the mines. Less palpable evidences of more skillful mining than that of any aborigines have been found in other shafts.

The Great Glacier of the Yellowstone.—Professor Archibald Geikie, Director of the Geological Survey of Scotland, gives in the "American Naturalist" an interesting notice, based on his personal observations, of the ancient glaciers of the Rocky Mountains. He refers to the absence of signs of glacial action in the region between the Missouri Valley and the Sierra Nevada, which has been mentioned by American geologists, and regards it as the result chiefly of meteorological conditions. Then, having spoken well of the accounts given of the glaciers of the mountains by our geologists, he records his own observations of them. Entering the Yellowstone Valley from Fort Ellis, a little above the first cañon, he observed a prominent rock like a cottage, and weighing more than a hundred and fifty tons, lying, like other smaller erratics around it, on crescent-shaped mounds—moraine-heaps—in the midst of the alluvial plain. The broad valley was full of moraine-stuff. Here, he observes, was a great glacier moving northward, "while in British Columbia, on a parallel only about two hundred and fifty miles farther north, there was a massive ice-sheet moving southward. It will be a point of no little interest to trace these two converging ice-streams toward each other." In ascending the Yellowstone Valley toward the National Park, scattered moraine-mounds and abundant transported blocks continue to denote the course and size of the former glacier. The intense glaciation of the second cañon was a surprise. The rocky knobs at the lower entrance of the great ravine were as perfectly smooth, polished, and striated as the rocks at the margin of any Swiss or Norwegian glacier, and the steep sides of the cañon had been ground and striated in the same way, to the height of certainly not less than eight hundred feet. Above the second cañon the moraine-heaps become more abundant and tumultuous, here and there inclosing small lakes; and they were found also, with erratics, in the tributary valleys. The trail from the Mammoth Springs by Blacktail Deer Creek, over to the Yellowstone, leads across mounds of glacial *débris* among which huge bowlders of granite and granitoid gneiss are conspicuous. Some parts of the route present long, smooth slopes, dotted with bowlders precisely like some Scottish bowlder-clay moors. These signs of glaciation can be traced up to and

across the water-shed leading over to the Yellowstone Valley, and "they prove beyond question that not only was that valley filled up with ice, but that the glacier plowed over the ridge one thousand feet above the valley-bottom and passed into the country lying to the westward." Professor Geikie made an estimate of the thickness of the ice, from the indications afforded by the position of the highest erratics which he observed on the slopes of Mount Washburn, from which he concludes that it could not have been less than sixteen hundred and fifty, and was probably at least nineteen hundred feet. It is clear to him, from all the evidence, that the ice of the Yellowstone Valley was more than that of a mere local or valley glacier. It was massive enough to fill up the main valley and override the surrounding hills, crossing minor water-sheds and spreading into adjacent drainage basins; and he believes it may be eventually shown that the snow-fields of the Wind River and Teton ranges were so extensive that their ice-rivers streamed northward across the buried water-shed, and poured into the Yellowstone. An exploration of the country lying in the Yellowstone Valley, northward into the area of northern glaciation within the British line, is desirable to show whether there was any connection between the glaciers of the Rocky Mountains and the great northern ice-sheet, and whether the latter, as it moved down the valley of the Missouri, was swelled by the accession of ice-streams from the mountains.

Structural Peculiarities of the Eel.—Frank Buckland gives an interesting description of the curious yet simple apparatus by means of which the eel is able to keep his gills moist without taking in fresh water, and thereby to live a long time out of water and travel on land for a considerable distance. Close to the pectoral fin of the eel is a slit which acts as a valve, connecting with a large cavity inside of which are the gills. This cavity the eel has the power of filling with water, and of keeping within it a supply which prevents the gill-fibers from adhering together so as to stop respiration. It is surrounded by a loose membrane, and is filled and emptied by means of a curious bit of mechanism which is thus described: "A framework of very delicate bones, each bone connected with its neighbor by an elastic membrane of the consistency of gold-beater's-skin, forms a fan-shaped covering over the gills; its action is very like, if not the same as, the action of an umbrella. When the eel wishes to take in his water-supply, he, as it were, opens his umbrella-shaped framework and fills his reservoir; when he wishes to expel the water, he, as it were, closes his umbrella." When an eel is taken out of the water he will soon expand his reservoir, and swellings will appear on either side of his head. He will shortly wish to refill his reservoir, and, if given water, will immediately take in a considerable quantity. With this he is ready to take an overland journey if he wishes to change his abode. The eye of the eel is protected against the mud, stones, etc., among which he lives by what Mr. Buckland calls a wonderful spectacle or eye-glass, formed by the conversion of the skin of the head where it passes over the eye into a thin but strong transparent membrane, which forms an admirable guard against injury.

Split Stones in the Desert.—Those parts of the desert of Sahara called the Hamadas—which are also among the most desolate tracts of the region—are strewed with silicious pebbles which are all broken up, presenting sharp edges, as if they had just been split with a hammer. Sometimes fragments of these pebbles could be found lying together with their fractured sides facing each other and fitting perfectly when brought close together. The phenomenon has baffled explanation for a long time. M. J. Brun has recently communicated to the Scientific Society of Geneva his conclusion that it is the result of a curious combination of chemical and mechanical actions. He found by analysis that the sand of the desert was composed of quartz, gypsum, and marl, with traces of salt. The quartz-grains act under the influence of the solar rays as burning-lenses upon the gypsum, and render it anhydrous. The sand and fine anhydrous gypsum-dust are driven about by the winds and cover all the stones; the dust penetrates the little cracks in the stones, when it is wet by the dews, and swells. With continuous ac-

cessions of gypsum and repeated heavy dews the accumulation of plaster goes on increasing, the cracks are enlarged, and in time the stone is split.

Variations in the Forms of Water-Plants.—Dr. W. Behrens, of Brunswick, has published a preliminary report of researches which he has been making into the influence of the movement, and other physical relations, of water upon the plants growing in it. He observes that water-plants, both those that grow submerged and those which appear on the surface, are subject to a variety of modifications in the forms of their stems, leaves, and other organs, according as the water in which they grow is in more or less lively motion. Plants which grow in a stream, and are rooted in the ground, seem to receive a kind of pull from the moving force of the water, which is proportioned to the speed of the current. If plants which grow indifferently in standing, moderately moving, and swift waters, exhibit variations which are constant for the same kind of waters, the conclusion is allowable that the variations are produced by the kinetic influence of the waters. Plants which are met in only one kind of waters do not exhibit equivalent variations. The common frogbit, of Europe, which floats on the surface of still waters, has its leaves always of the same broad kidney-form. The pondweed, which grows both in still and running waters, exhibits, on the other hand, manifold variations. The most common form has floating, oval leaves, the diameters of which are to each other as 1 to 1·5. The leaves of those varieties that grow in running water are longer and narrower in proportion to the swiftness of the stream; and one form is mentioned in which the diameters of the leaves are as 1 to 3. The water-ranunculuses (Batrachium) afford excellent examples of the influence of running water on the forms of plants. Several species are found in all kinds of waters, the most of them having leaves of two forms, peltate floating leaves, and much divided submerged leaves. They grow in still and running, fresh and brackish waters, and even on the land after the water has dried away. Of the species common in Europe, *Batrachium aquatile* is the most interesting object of study in respect to its variations. Its forms are numerous, but they may be arranged under two general heads. The first includes those varieties which have plain floating leaves and also divided, submerged leaves, and the second those which have only divided leaves under water. The forms of the former class occur principally in waters having little motion; the floating leaves are round and peltate, with fine slight scallops on the borders. In swifter waters the leaves are cut up into pointed lobes, the distinctness of which increases with the speed of the current. Dr. Behrens has distinguished about thirty varieties in different waters, most of which he has described and named in his paper. In the swiftest currents, the floating leaves disappear, and only the varieties of the second form—those having exclusively divided, submerged leaves—are found. Still another change comes over the Batrachium when the water is taken away from it. It grows up with a short stem, and is thickly covered with green leaves divided into numerous short, firm, succulent lobes. Dr. Behrens is preparing a work in which variations of this sort will be fully discussed, with illustrations.

Progress in Photography.—"Some Recent Advances in Photography" is the subject of a paper recently read before the Society of Arts by Captain Abney, R. E., F. R. S., in which reference was made to the more important improvements in the art that have been put in practice since 1875. A new negative process, called the gelatino-bromide process, offers decided advantages. It consists in the use of a gelatine emulsion of silver bromide for the sensitive surface. With a plate thus prepared, a photograph may now be taken in one second of time which it formerly took thirty seconds to secure; and a plate can be prepared which needs an exposure of only one sixtieth of a second, when a view is fairly lighted to secure a soft and harmonious negative. It makes instantaneous views possible under circumstances which were impossible, in illustration of which the speaker exhibited a view in which the shadow and reflection of a swallow passing in the air over a pond were perfectly represented. The plates and the development of pictures

taken by this process are perfectly clean. The plates, moreover, have the quality of preserving the impressed image for a long time after they have been exposed and before it has been developed. The chief disadvantage of the process is that the photographer using it has very little power to give local intensity to his picture. Till lately, a red light had to be employed in the developing-room, and this was painful to the operator. The difficulty has been obviated by adding iodide of silver to the emulsion in the proportion of one part of iodide to eight of the bromide, when an orange light can be used with impunity, and the shadows are given a wonderful clearness. When a collodion emulsion is adapted to a flexible support and used for the negatives, the operator is able to do away with glass and its weight, and may store rolls of sensitive material in the camera itself. Then, by turning a screw, he may place fresh portions of the band in a condition for exposure. After exposure, paper prepared with this emulsion may be moistened with turpentine, and the film bearing the image, almost free from weight and bulk, may be stripped off. To print from these flimsy negatives, it is only necessary to place them on glass. When a flexible support shall have been introduced for the gelatine emulsion, the negative processes of photography will be almost perfect. With the collodion emulsion, we are able to get a physical condition of the bromide, in which it will answer to the vibration of the rays of the lowest refrangibility. Photographs of the solar spectrum taken on this salt were shown, corresponding to wavelengths which lie more than three times as far below the red as the distance of the visible spectrum. This process is being applied to the examination of different colorless bodies, with a view of obtaining spectroscopic analyses of them. It has been discovered that the photographic image is rendered undevelopable by the action of oxidizing agents, and this alike whether it be produced on a collodion or a gelatine film or on paper. The oxidation of the image goes on also in ordinary atmospheric conditions, more especially under the influence of light, and in it we have a simple explanation of what is known as solarization. A platinum process, in which an image is produced in platinum-black, is about four times as sensitive as the ordinary silver process, and marks the greatest advance in printing that has been made for many years. Another printing process is based on the reduction, by ferrous oxalate, of bromide of silver which has been exposed to light, and was discovered almost simultaneously by Mr. Willis, of England, and Mr. Carey Lea, of Philadelphia. The prints obtained by this process have great permanence, since no organic compound of silver, the great agent of deterioration, is present in them. Mr. Lea has discovered within the last year that the power of development which is shared by most of the organic salts of ferrous oxide is not limited to them, but is possessed also by many of its inorganic compounds. He gives a brief account of his researches in this direction, and of the properties of the different salts of the oxide, in the "American Journal of Science" for June.

The Regulation of Visual Tests.—The Boston "Herald" published last summer a review of what had been done in the United States during the previous twelve months to secure protection against the dangers arising from color-blindness and visual defects in seamen, railroad-men, and other persons occupying positions of trust in which the quality of eyesight is important. Three departments of the national Government have adopted regulations on the subject. The War Department has ordered the examination of recruits by test-cards, to test their power of distinguishing objects at a distance, and with worsteds for their perception of colors. The Treasury Department has made the examination of all pilots, as to their ability to distinguish colors, compulsory, with the provision that "a second visual examination will not be required in any case." The Navy Department has ordered a similar examination for all persons in the navy, or who may hereafter enter it. The House Committee on Naval Affairs has reported favorably on a petition of Dr. B. Joy Jeffries and others for the enactment of a general law of control for the naval and merchant service, and for a representation of the United States in an International Congress to agree upon definite standards of color-tests, and has reported a

bill authorizing such representation, which will come up at the next session of Congress. One steamboat company and one railroad company have instituted a compulsory examination of all their men. The State of Connecticut has adopted a law for the examination of railroad-men, with the following requirements for a certificate in the first class (engineers, firemen, and brakemen): 1. Healthy eyes and eyelids without habitual congestion or inflammation; 2. Unobstructed visual field; 3. Normal visual acuteness; 4. Freedom from color-blindness; 5. Entire absence of cataract or other progressive disease of the eye. For second-class certificates (conductors, station-agents, switchmen, etc.) the first two conditions are the same, but in the third condition is required only "visual acuteness at least equal to three fifths without glasses and normal with glasses in one eye and at least one half in the other eye, with glasses," and in the fourth "freedom from color-blindness in one eye, and color-perception at least equal to three quarters in the other eye."

Form of the Lightning-Rod.—The subject of the proper form of lightning-conductors, long a disputed one among scientific men, has recently been experimentally investigated by Mr. W. H. Preece, with the result of confirming the position of Faraday, that the section of a rod is the essential element. The advocates of rods of large surface, such as ribbons, tubes, etc., among whom was the late Professor Henry, conclude, from the fact that static electricity resides upon the surface, that electricity of high tension, such as a lightning-discharge, is better conducted away by a large extent of surface. Mr. Preece stated that no direct experiments had, so far as he was aware, ever been made to settle the question, which was an important one, as the acceptance of the surface theory had led to the employment of unsightly and costly conductors, when a simple rod would answer all purposes. The experiments were made in the laboratory of Dr. Warren de la Rue, and had the advantage of his advice and assistance. In the first experiment copper conductors thirty feet in length, in the form of a solid rod, a thin tube, and ribbon, each of precisely the same mass, were used. The electricity was obtained from 3,240 chloride-of-silver cells, and accumulated in a condenser of a capacity of 42·8 micro-farads. The sudden discharge of this quantity of electricity produced results similar in character to lightning. It was capable of completely deflagrating 2½ inches of platinum wire of .0125 inch diameter, and of raising to different degrees of incandescence greater lengths. Such wire, affixed to a white card so as to record the effect, was used to measure the discharge after it had passed through the conductor. Each form of conductor gave exactly the same result in the deflagration and heating of the platinum, showing that different extents of surface had no effect. As it might be thought that, in copper conductors of such length as those used, differences in conductivity could not be readily detected, the experiments were repeated with lead conductors, the resistances of which were twelve times that of copper, with the same results. An experiment, to determine how closely variations in the discharge could be estimated, showed that a change of resistance of five per cent. could have been easily detected. Mr. Preece, therefore, concludes that no more effective lightning-conductor than a simple rod or wire rope can be devised.

The Phenomena of Thunderstorms.—In a recent lecture at Glasgow, Professor Tait reviewed the present state of our knowledge of thunderstorms, and pointed out the chief conditions upon which the phenomena seemed to depend. The different degrees of conductivity of the air to which the zigzag form of the flash is due he thought might be produced by local electrification, which would have the same effect as heat in rarefying the air and making it a better conductor. Sheet-lightning is probably the reflection of a flash of forked lightning, itself invisible to the observer. Summer lightning is, in some cases, of a similar character, but in others, when the sky is clear, it seems to be due to discharges taking place in an upper strata of the atmosphere, the thunder being inaudible both on account of the distance and its originating in an atmosphere of but small density. The discharge in the form of a luminous ball is of rare occurrence, and but little is known of

it. It is probably a natural form of Leyden jar very highly charged. The light of a flash, Professor Tait states, is of very much greater intensity than is commonly supposed, the apparent brightness being, on account of the exceeding small duration, less than one hundred thousandth part of what it would be if the lightning were permanent. This duration is not more than the millionth part of a second, and hence it is a mistake to suppose that you can see the direction in which the discharge is passing, whether from the clouds to the earth or from the earth to the clouds. Professor Tait insists upon the necessity of properly pointing and grounding lightning-rods to secure safety, and mentions several instances of the ignorance in this matter which seems to prevail among even well-educated people. In one case the point of the rod was actually covered with a glass insulator. The best ground connection is with the water-mains, but large masses of metal or other conductor in a moist soil answer when these are not at hand. Connection with a body of water inclosed in a masonry basin, such as a reservoir, is not a proper way of grounding the rod. A lightning-rod acts as a constant drain upon the charge in the clouds in its neighborhood, and when the rods are numerous over any area, as in a well-protected town, storm-clouds will pass over without any lightning-flashes taking place, though such form of discharge will occur before reaching the protected district and after passing it. The lecturer insisted that people should regard the use of rods as both a public and private duty. In regard to the sources of electricity in the atmosphere, Professor Tait has been led by experimental researches to infer that a separation of the opposite electricities occurs simply by the contact of particles of air and aqueous vapor, which, on the kinetic theory of gases, are in constant collision. In the same way zinc and copper become oppositely electrified when brought into contact. The precipitation of vapor-particles into cloud-particles and the agglomeration of these into rain-drops enormously increase the electrification, as the potential of a free charged sphere is proportional directly to the quantity of electricity on it and inversely to its radius. The separation of these highly charged particles of air and water is effected by gravity and the diffusion of gases which would cause the air-particles to escape from among the mass of precipitated vapor to the less highly electrified air above. Sir William Thomson has offered an explanation of the phenomena, based upon the fact that the lower air is usually negatively charged. Ascending currents carrying this air upward, the electricity, which was formerly spread out over a large area, may by convection become so much less diffused that it will be raised to a high enough potential to give a spark. However the electrification of the precipitated vapor occurs, there is no question about the fact that, clouds once formed, the particles are electrified. The solution of the problem of just how this is brought about must in all probability come through experiments made on a larger scale than any so far conducted in the laboratory.

Science in the Schools of France.—The modifications in the course of studies in the French public schools, recently decreed by the Superior Council, give to scientific teaching a more prominent place than has hitherto been allowed it, especially in the elementary classes. In the seventh class, the elements of the natural history of animals and plants are added to the history of soils and stones, and take the preference over it, as offering more interest to children and being of greater practical utility. In the sixth class, an hour is deducted from the ten devoted to Latin and added to those given to the sciences, which are allowed four hours a week. In the fifth class, where scientific instruction has been obviously deficient, the hours for Latin are reduced to five, and the sciences are given four hours. In the fourth class an hour is taken from Greek, and the hours for scientific instruction are increased to four. Scientific instruction will be continued in the third, second, and rhetorical classes without encroaching upon the other courses, an hour being taken from the study-hours for new subjects of natural history in the third class, for physics in the second class, and for subjects of physics which have not been previously entered upon by the pupils, in the rhetorical class. The Superior Council advises that the teach-

ing of mathematics and the natural sciences in the grammar-classes be committed to special professors whenever the funds of the school will permit it and suitable teachers can be obtained; otherwise, professors of science in the higher classes may perform the duty for an additional compensation; or, if there is no other way, the ordinary professor may provisionally give the special instruction.

M. Faye's Theory of the Crust of the Earth.—M. Faye has propounded a new theory of the internal structure of the earth, an important feature of which is that its solid crust is much thicker under the seas than under the continental masses. The oscillations of the pendulum and the direction of the plumb-line are known to be subject to variations in consequence of the neighborhood of a mountain, or even of a hill, calculations based upon which enabled Maskelyne to determine the density of the globe. When, however, experiments with the plumb-line and pendulum were applied to table-lands and to the grander mountain-ranges, the deviations corresponding to the magnitude of the masses which were expected were not shown. The pendulum which is sensitive to the presence of the Great Pyramid of Egypt gives no sign of the neighborhood of the Himalayas. Further than this, a real deficiency of attraction has been observed upon continents, as if there were a great hollow under them; and the failure of mountain-masses to deflect the pendulum has been actually attributed to the existence of cavities in them. On the other hand, when the investigation is transferred to the sea, the weight is found to be too great, and is in excess of what is demanded by theory, as evidently it falls short of it on the continents. Hence, if we suppose that there is a lack of matter under the continents, we must also suppose that there is under the seas an accumulation of it above the average for the whole earth. M. Faye suggests, to account for these contradictions, that the cooling of the earth is going on faster and has taken place to a greater depth under the oceans than under the continents. The temperature at 12,000 feet of depth below the sea is a little higher than the freezing-point; at the same depth under the continental masses it is computed to be about 300°. The matter is kept at this temperature by the superior strata of earth almost impermeable to heat, and through which the heat that actually escapes is hardly perceptible. The crust of the earth in such a situation can increase in thickness only at the slowest. Under the sea, on the other hand, matter at the same depth is in almost immediate communication with a cold of the freezing-point, and, instead of having some non-conducting strata above it to prevent its escape, the heat is immediately absorbed in a cold of polar intensity. A similar difference exists deep in the beds of the submarine rocks, for the water is imbibed in their pores to a greater depth than in the sub-continental rocks, and the heat is conveyed away from them by the vertical convection of the warmed water rising in them. The more ancient the existing beds of the sea, the greater is the thickness of the crust that supports them as compared with that of the continents.

Trichinosis on a British School-ship.—A remarkable outbreak of trichinosis on the British reformatory school-ship Cornwall has recently been brought to the notice of the Government health boards. Up to the 23d of September last, the health of the boys had for a long time been good, but, between that day and October 23d, forty-three boys were taken sick, falling ill in batches—seven on the 23d, two on the 24th of September, sixteen between the 29th of September and the 1st of October, nine between the 3d and 6th, and the rest at intervals. The outbreak was regarded as one of enteric fever, and the general character and progress of the disease seemed to justify the view. No cause, however, likely to produce such an outbreak could be discovered. The hygienic condition of the ship was perfect. The inspector turned his attention to the food, and found that none of the officers, who were supplied with distinct food from the boys, were attacked. The boys from a particular mess suffered more than the others, and the tendency of the groups of fresh cases to occur on certain days of the week suggested a connection between the attacks and the salt pork that was served out on Mondays. The body of

one of the boys who had died was examined, and the microscope showed living trichinæ in his muscles, but none of the appearances of enteric fever were discovered. A new cask of salt pork had been opened just before the disease appeared, the meat from which is supposed to have communicated the trichinæ to the boys. This view is confirmed by the fact that the disease ceased soon after the use of the pork was stopped. The method of cooking the meat on the vessel seems to have been defective and not sufficiently thorough to insure the heating of the whole mass to the temperature at which the trichinæ are destroyed.

Sensitive Organs of Deep-Sea Animals.—M. O. Grimm has sought to explain how it is that we find in the great depths of seas and lakes animals without eyes, and besides them others in which those organs are highly developed. According to his view, the light received by animals living in these depths is extremely feeble, but is never totally wanting. An adaptation to these special conditions has taken place. With certain crustaceans, the eyes have gained a considerable volume; with others, the eyes tend to disappear and to be replaced by other sensitive organs. In the Niphargus and Onesimus, for instance, the existence has been detected of extremely developed sensitive organs which may be supposed to serve as organs of touch, taste, and smell. *Niphargus Caspius* has very small eyes, which can hardly be considered as anything but the remains of normal organs, and can hardly be of any use to an animal living at a depth of from thirty-five to ninety fathoms, but it has highly developed organs of smell and touch on its antennæ. The Onesimus, whose eyes are also very rudimentary, have neither on the antennæ nor other parts of the body sensitive organs like those of the Niphargus, or at least such as they have are very little developed; but a close examination will discover, on the external blade of their foot-jaws (maxillipedes), well-constituted organs of sense, although they are hidden and of a very different structure from those of Niphargus. In explanation of this difference in the nature of the sensory organs of genera so nearly related to each other, M. Grimm remarks that the species he has found with organs of sense on their antennæ always live in the water and never go into the mud. The Onesimus, on the other hand, keep constantly in the mud of the bottom and seek their food by digging, as the moles do. Under such conditions, delicate organs of sense on the antennæ would be of no use, and have become nearly obliterated, while the situation has favored the development of organs in a protected position.

NOTES.

The next meeting of the French Association for the Advancement of the Sciences is to be held in the city of Algiers, on the 14th of April. The people and authorities of the city are busily making preparations to give the Association a worthy reception and welcome. Liberal appropriations have been made by the council for the material organization of the meeting, and a large committee of citizens, under the presidency of M. Pomell, Senator and Director of the Superior School of Sciences, is preparing a programme of excursions, which will be well filled out. M. Chauveau, Director of the Veterinary School at Lyons, will be president, M. Janssen, the astronomer, vice-president, and M. Maunoir, of the Geographical Society, secretary, of the meeting.

We have news of the recent death of Michel Chasles, the eminent French mathematician. M. Chasles was the author of an historical memoir on the origin and development of methods in geometry, and of numerous works in pure mathematics, and in 1865 received, in recognition of his discoveries, the Copley medal of the Royal Society.

The name of the author of the useful little work noticed in our last number, under the title "What to do first in Accidents or Poisoning," is Charles W. Dulles, not Dallas, as it was there erroneously printed.

The death is announced of Dr. John Stenhouse, F. R. S., a distinguished Scotch chemist, at the age of seventy-one. He was a pupil of Graham, Thomson, and Liebig, held the chemical lectureship at the Medical School of St. Bartholomew's Hospital, London, for six years, and was subsequently appointed non-resident Assayer of the Royal Mint. He wrote a large number of papers on chemical subjects, and was the recipient of a medal from the Royal Society, of which he was long a member.

According to the researches of Gustav Hausen, the antennæ of insects are organs

of smell. He found that, on their removal or when coated with paraffine, the insects became quite indifferent to the most odorous substances—flies, for example, when thus treated, taking no further notice of tainted meat.

PROFESSOR ERNST HAMPE, the distinguished German bryologist, died at Helmstedt, November 23d, at the age of eighty-five.

THE "Revue Scientifique" acknowledges that the meetings of the French Association and the British Association will have to yield place, for 1880, to that of the American Association for the Advancement of Science, which excelled on account of the importance of the subjects discussed, and was also marked by a numerous attendance and the manifestation of a great interest in its proceedings.

AN International Congress of Electricians has been called by the French Government, to meet in Paris on the 15th of September, 1881; and an International Exposition of Electricity is to be opened on the 1st of August and to be closed on the 15th of November. The Government leaves the expenses of the Exposition to be paid by those who participate in it, but it is believed that the whole financial responsibility of the affair will be assumed by a French capitalist. The preparations for the Congress and the Exposition will be under the direction of M. Georges Berger.

THE notion that the blood-capillaries receive material support from the tissues in which they are imbedded is contradicted by the researches of Ray and Brown, an account of which is published in a late number of the "Journal of Physiology." According to their experiments, the extra-vascular pressure is but slightly, if any, greater than that of the atmosphere; that is, if the surrounding tissues were all removed, the capillary walls would be no more likely to give way from internal blood-pressure than they are under normal conditions.

PROFESSOR J. C. WATSON, Director of the Observatory at the University of Wisconsin, died on the 23d of November of last year. He had acquired a high reputation as an astronomer, both here and at the University of Michigan, where he was formerly engaged, and was best known, perhaps, by his discoveries of twenty-one of the asteroids, by his work in the observation of the transit of Venus, and the solar eclipse of 1878, and by the interest he took in the search for the supposed planet Vulcan.

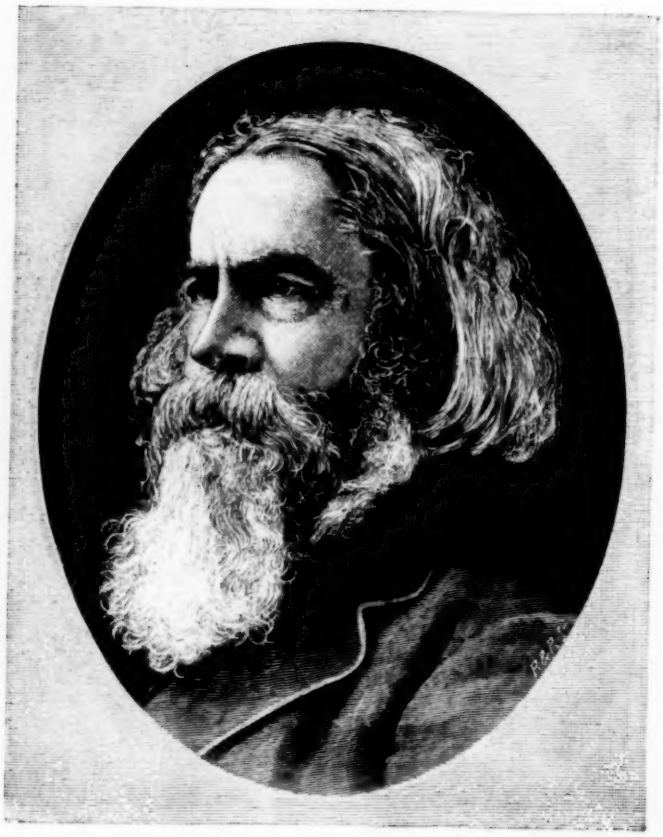
THE equipment of the observatory now in course of construction at Nice will comprise two equatorials, one meridian, and several accessory instruments. One of the equatorials will probably be the largest astronomical apparatus in the world. Its focal distance will be about sixty feet, and its aperture thirty inches. The cupola will have a diameter of seventy-two feet. The object-glass is to be constructed by MM. Paul and Prosper Henry, of the Paris Observatory. The instrument alone will cost 250,000 francs, and the entire observatory at least 2,000,000 francs.

PROFESSOR ALPHONSO WOOD, author of several works on botany, died at West Farms, New York, January 4th, aged seventy-one years. He was a graduate of Dartmouth College and Andover Theological Seminary, and spent much of his life as a teacher, having had the charge of schools at Meriden, Connecticut; College Hill, Ohio; Terre Haute, Indiana; and Brooklyn, New York. For the last two years he was Professor of Botany in the College of Pharmacy in this city. He began the publication of his botanical writings in 1860. His best-known works were: "The Class-Book of Botany," "Object-Lessons in Botany," "The Botanist and Florist" "The Plant Record," and "Flora Atlantica."

A NEW process of tanning, in which bark is wholly dispensed with, and inorganic compounds are used in its place, is coming into use in Germany. The special feature of the process is the action of chromic acid, for the generation of which a number of substances, all soluble in water, are brought together in the mixture so as to effect the decomposition of bichromate of potash. The new process requires only from four to six weeks for its completion, against the several months needed in the bark-process. It has been tried at an experimental tannery in Glasgow, Scotland, with favorable results.

BENJAMIN COLLINS BRODIE the younger, F. R. S., died on the 24th of November last. After taking his master's degree at Oxford in 1842, he went to Giessen to pursue original chemical work under Liebig and first distinguished himself by the publication of his analyses of wax. He became an industrious investigator of the changes undergone by the molecules of different substances, and of the modes of combination, and had an important part in the development of the present theories of chemistry

PÈRE ANTOINE HORNER, the founder of the French Roman Catholic mission and agricultural establishment at Bagamoyo on the Zanzibar coast, has recently died at Cannes. He made long journeys of exploration in the interior of Eastern Africa, in recognition of the scientific results of which he was elected an honorary corresponding member of the Royal and several other geographical societies.



BENJAMIN PEIRCE.